MANAGEMENT MODEL FOR DISCONTINUOUS SYSTEM ON SURFACE MINES

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ABSTRACT

The mining industry in the 21st century needs fundamental changes in both technical and management technology, because many unresolved mining issues lead to building a structured and directly applicable management model that would be managing tool by the mine production system.

The aim of this paper is to define a model for the management of discontinuous surface exploitation systems. Key components of the methodology include: defining and accepting managing matrices, basic and auxiliary operations; centralized and integrated data infrastructure, a set of production performance metrics, data processing and management infrastructure.

In this sense, information technologies and management techniques have been used, with detailed research of the discontinuous exploitation system and specificities with a huge number of influencing parameters and variables that greatly define the way of this management process

Key words: *model, management, discontinuous systems, dispatching, simulation*

GENERAL PART

Exploitation of mineral resources can not affect many factors, such as geological characteristics of deposits, prices of mineral raw materials on the market, meteorological conditions, existing infrastructure or legislation. Therefore, the improvement of the business performance of production systems is achieved with activities aimed at cost reduction, optimization of production processes and greater utilization of existing resources. The productivity of the mining production process depends to a large extent on the interdependence and interconnection of individual parts of the process and equipment, and the optimization of the process is difficult to perform without the computer support in the control system [1,2,3].

Modern trends in the information technology favor the orientation towards integral supervisory information and management systems, whose basic characteristic is the orientation to the business and technological functions of the real system and a unique database related to events that are relevant to the real system. Such an approach provides the control possibility over the entire real system, whereby information for certain subsystems is dynamically derived from data generated by other subsystems [4,5,6].

The importance of information technology (IT) in all areas of human activity, especially in largeindustrial systems, has been increasing exponentially for several decades. In modern business conditions, there are more and more systems that do work on IT in their business and management. Thus, in the field of mining, information technology becomes an indispensable element of business, which opens new perspectives for improving production [6,7].

Realization of an information system, but also an effective management model, requires knowledge of a series of diverse disciplines, as well as knowledge needed to evaluate and model future behavior of the real system and its surroundings. With the introduction of information technology we [8,9]:

- Provide instant updatability of data and reduces the error possibility
- Reduce the engagement of people in routine and manual activities
- Establish links between planning, operation and job scheduling
- Make a quick selection of desired information and creation of various statistical and other reports on business events at all levels of management in order to achieve the timeliness and correctness of management decisions, and
- Improve cost control and increases overall productivity and business efficiency

Systematic improvements in the management of surface exploitation of mineral resources production operations, as optimization of production in surface exploitation have been so far focused primarily on achieving better economic effects through mass production rather than modification of the production system itself.   .

The production management system makes the heart of the mine, and today the largest part of education and research in mining is dedicated to everyday production and strategic issues such as the mineral raw materials market, the slope stability, the environment, the design of the mine, the automatization, equipment, etc. As the real reserves of most of the mineral resources continue to decline, the survival of the mining industry in the 21st century requires essential changes, both in the technology of production and in management technology. Innovation in these two sectors opens up opportunities for other industry sectors to remain profitable [8,10,11].

The production sector mainly focused on the production and control systems that essentially affect the value of the product. Such a focus on the production management system has led to the development of production and management techniques that can increase productivity, quality, and through efficient cost management and mine profitability.

SUBJECT AND METHOD OF WORK

Management in mining are the instructions and controla of the mining production system, in order to fulfill the business goals of the company and owner. The coal mine should be seen as a business in which the profit of the company on the mine, is the primary interest of the management, within the framework of social and ethical limitations, as well as environmental restrictions[1,2,5].

Operational issues on the surface mine include the planning, exploitation and production of mineral raw materials management in terms of: making decisions on the duties of employees in the handling and maintenance of machinery and equipment, elimination of delays in production, monitoring, controlling and reducing unit costs, etc.   .

The influence of a large number of factors (working environment parameters, technology of exploitation, capacities and equipment condition, equipment and labor location, organization, efficiency and detailed operational system operation costs) require the application of different mining technologies and complicates the management of surface exploitation systems. Optimizing the management of discontinuous surface exploitation system is a very complex process and complex matter requiring precise definition of all relevant indicators that affect the operation of the open pit as

a whole. The modernization of management in most of the mines is conditioned by production control and management mechanisms [8,10].

The objective of optimizing the management of discontinuous surface exploitation systems is get the managing system as closest as possible to the given state, and that can be achieved by increasing the number of changes in the input parameters. When the optimal solution zone is identified, the step of changing the input parameters is gradually reduced, which can result in an optimal solution by continuously using the simulation results on the basis of real-recorded parameters from the original proprietary system. Defining the management model is focused on the unique aspects of the mine management of production processes. Surveys carried out to fulfill the objective included [8]:

- Research into the history and complexity of modern management techniques for product management
- Identifying the diversity of mining management systems in relation to other industries
- Research on utilization possibilities of modern management techniques in the mine production systems
- Study of existing methodologies for modeling, analysis, management and optimization
- Verification of methods based on practical results and knowledge of previous theoretical research
- Development of an integrated approach to the management and optimization of discontinuous surface exploitation systems in the function of long-term planning of the open pit
- Presentation of the developed model on the example of a discontinuous system of surface exploitation of the open pit "BogutovoSelo"
- Analyzes of the achieved results and grades

MODEL OF DISCONTINUOUS SYSTEMS OF SURFACE EXPLOITATION MANAGEMENT

Mining production has significant benefits from the information and the possibilities of monitoring and control of the work process. Technological improvements of mining companies in the form of integrated enterprise networking systems have created the potential for creating cheap, easily accessible and accurate information. Easy access to information allows operators to adopt new process optimization techniques. However, there are several limitations for the application of these techniques in the mning industry, and they are, [1,5,11]:

- Not all techniques are applicable in any situation (for this reason the technique must be adapted to the system in which it is used)
- The limitation of the mentioned optimization methods stems from the fact that they are not applicable in mining in their original form (the mining environment is different from the production, in terms of resource consumption and planning, production control, labor requirements, process inputs and culture)   .

The appropriate methodology initially identifies and analyzes modern management techniques, the industries that have produced them, and the factors that led to their success. The characterization of the current mining production management systems also identifies their most important deficiencies, as well as the differences in comparison with those industries that were more successful in controlling production.

Every open pit design solution and selected technology and mining equipment have several transformations-designs for the working life, primarily for the sake of new knowledge about the deposit and accompanying rocks and layers, the development of technology and the machine industry into the world as well as to changes in the prices of the drive energy. According to the approach presented in this paper, there are various problems that are solved by the use of information technologies, and they are presented by Equipment Selection, Network Design, Vehicle Routing, location of the main point / narrow- Hub Location, Scheduling and Allocation of equiment [2,5,6,7].

Modern world technologies and development in the high-productive mining equipment have opened up great possibilities in the systems of surface mineral raw materials exploitation, although the mining and geological conditions at the mineral deposit beds are more complex from the aspect of structural, engineering-geological, physical-mechanical and hydrogeological characteristic. Optimizing the management of discontinuous production systems implies quick and efficient information gathering across all segments, selection of information received and decision making that will give optimum results at a given time with the exploitation costs that provide maximum profit. Based on information quality efficient management of production processes and the quality of mined raw materials are enabled. The development of computer equipment has enabled a quick and efficient way of creating a model for optimizing production processes, managing production costs and minimizing costs.

Taking into account the large number of information circulating in the management systems, it is necessary to introduce the automation of production management. The rapid development of computer science and related software allows deposit modeling and parts or overall technological production processes on open pits. Maintaining optimum production values in time under variable conditions is a continuous optimization procedure, which must include all relevant factors by setting an appropriate methodology. A model for optimizing the management of discontinuous surface exploitation systems with an economic rating implies an analysis of a large number of possible equipment combinations, work technology and organization in the function of short-term and long-term planning of production on a given mine [8,12].   .

In the first phase of the survey, a review of management techniques adopted in all industries should be performed to identify key management techniques and infrastructure requirements necessary for the application of these techniques. An overview of tactical management in mining operations helps in identifying the deficiency in both infrastructure and standard management systems. With designing is possible to get a methodology for developing key management model components that elude problems in existing systems and provide the benefits of modern management techniques.

In the second phase are analyzed the development and implementation of the management model in a particular mine. In this section is perfomed a definition of management model composed of NIS and an operational-simulation part , which also forms the control part of the management model. It presents the list of the software packages that are used, and whose justification for use for these purposes should be verified in the case study.

Concepts of mining production management are reduced to the most detailed introduction and definition:

- work organization- management and organization of work in mining production meansmore precisely distinguishing which tasks constitute the activity and how much they are inthe process, because the mining production is composed of a certain number of processes,
- management of the mining production system - mining management deals with issues andprocedures that maintain production from day to day or from month to month. It isimportant to define the scope of the decisions of each decision-making level,
- objectives and scope of the modeling methodology - the modeling methodology of openpit mine management with discontinuous production systems develops key components ofthe management system, which include a system plan and infrastructure , benchmarks, management infrastructure, and operational part of the model that makes itmuch easier to make decisions,
- characteristic of mining production - the key reason why modern management techniquesremain unused completely in the mineing are the cultural, sociological, technological andorganizational differences that exist between mining and those industries where thesetechniques have been developed,
- the availability of information through the information system - the availability and structure of information constitutes a crucial difference between the service industries ormanufacturing and mining industries. The development of information technology (IT),suitable for this industry branch, remains a major focus for many mining companies,

- the use of information technologies in simulation modeling and dispatching ofdiscontinuous surface exploitation systems - a detailed description of a set of input data andcomponents, basic assumptions, and general structure of the simulation program. Input dataare one of the most important aspects in the implementation of any simulation study.Modeling the shovel-truck system through computer simulation has been used for manyyears and has wide application. There are manualy monitoring systems, semi-automaticsystems and automated dispatching systems. Each dispatch system has two main components: dispatch criteria and dispatching strategies.

DEVELOPING A MODEL OF OPEN PIT MANAGEMENT WITH DISCONTINUOUS EXPLOITATION SYSTEM

Developing a management model for all open pits is not feasible, since culture, working conditions and processes are unique to practically every mine [3,8,13]. In presenting new management techniques, those who have developed them most often present basic guidelines or methodology, to discuss key components of new techniques. The key components of the methodology include:

- defining and accepting control matrices, basic and auxiliary production system operations through which both the management system and the production system can be continuously improved,
- centralized integrated data infrastructure that will enable these changes and which is based on working process technology , as a basic source of data and information, in order to provide the data and information necessary for managing the entire organizational system in its its business and production
- a set of product performance metrics and defining elements of technical support to the basic model, and
- management infrastructure that takes care of the correct use of the menaging system through defining the implementation phases and designingthe support program for   individual implementation phases and introduction into exploitation.

The application and success of the managing model depends on the development of the management system in parallel with the mining system. The logic of the methodology is organized in two basic units:

- logistical-informational with three phases of development, and
- operational- simulation with one phase and two sub-phases of the model development. In essence,these four phases are organized in two partsand provide sufficientdata for structuring the management model and the correct information flow and exchange with satisfied results (Figure 1)

The phase of planning and the construction of the system infrastructure - the strategic plan for the management of discontinuous surface exploitation systems model development, observed in the entire mine operation system, is crucial for the long-term effectiveness of these systems. At this stage it is necessary to implement some other activities such as: the layout of the system, the creation of a production team (representatives of mines and IT companies), the determination of the data infrastructure, the development of a data model, the flow of data to the process map, identifying data sources, defining the input mechanism data.

Phase of determining impact measures - there are two traditional effect measures: production (t or m^3) and mining costs (KM/t or KM/m^3). Most mines have systems for costing and measuring performance, and this is important because decisions to increase or maintain production should be based on accurate and relevant information. Within this phase, it is necessary to: design measures of performance for the control system, determine diagnostic measures for process improvement, organization and production management with carefully designed objectives.

The stage of building a management structure - in order to use the management model, managers have an obligation to review information, and make decisions that are made by certain solutions. At this stage, the establishment of a control infrastructure, determination of process matrices   , responsibility matrices, and design of the control system model are carried out. All portions related to quality assurance and environmental protection, health and safety at work as well as all management processes, and auxiliary processes and basic processes in production are described.

Operational phase - defines issues related to the manner of use, maintenance and future development of management models, whereby it attaches importance to the efficient collection and statistical data processing from the production process itself, and the use of the simulation model that gives estimates of the behavior of the system in the future. It makes easy decision-making for management. Planning, designing, monitoring and managing production systems are intensively relying on the use of mathematical-logical models of real systems. Models of real systems are based on knowledge of the characteristics of certain technological operations and the rules of their interdependence. By developing a simulation model, we try to capture relevant system characteristics and adequately describe their changes depending on the changes in the state of the system.

By defining the structure of the integral information system on the example of the Ugljevik Coal Mine and the open pit BogutovoSelo, a tool for efficient and timely collection of current, reliable and precise information is set up in a clearly defined set of information, which further provides a multi-criteria approach to discontinuous production process simulation modelinge, dispatching and managing them.
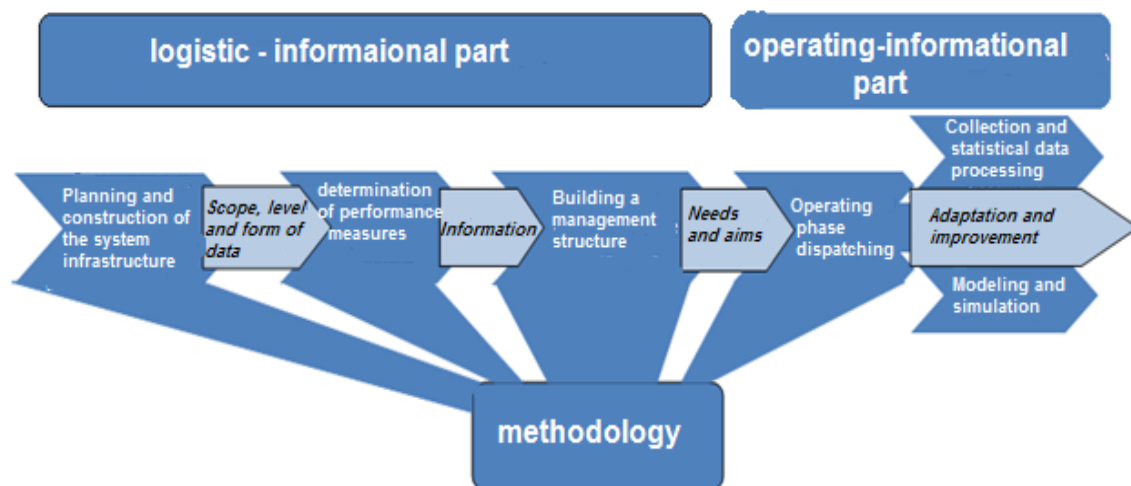

Figure 1. Development of management model stages [8]

Simulation analysis on the NIS database in order to improve the operation of the discountinous exploitation system - Most real systems that are analyzed by the simulation modeling method have a stochastic character of the input (eg, the arrival of trucks for loading), as well as internal stochastic components (eg truck loading time) [1,2,6,10]. Simulation models transform the stochastic impact that it receives from inputs and internal processes into the statistics that represent their output. When it comes to the analysis of the results, the simulation is simply a method of statistical sampling and analysis with certain specifics. The built-in stochastic in the simulation model through the input data determines the stochastic nature of the simulation results.

 In order to present the developed model and methodology for analyzing the possibilities of improving the efficiency of the work of the discontinuous systems in the minelife, since the working conditions are constantly changing (increase in haulage lengths, haulage height, changes in work norms etc.), an example of the work of discountinuous systems on the waste production   on the example of BogutovoSelo mine during 2015. For the above reasons, historical data on the efficiency of the system of shovel-trucks for a certain configuration of the surface mine BogutovoSelo were taken into account

(Figure 2). The analysis was carried out by comparing the fixed mode of operation of the truck with two possible approaches to improving the operation of these systems, [6,8].

- Minimizing the truck haulage cycle, and
- Minimizing the shovel waiting time.

Statistical analysis of input data for the simulation model - It is important to use data that accurately reflect the reality for the simulation of the real shovel-trucks system. It is very difficult to generalize the input data in order to make the model universally applicable. In general, each surface mine uses different types and sizes of loading and haulage units, the number of landfills, the configurationof the transport routes network and therewould be practically impossible to define a generalized group of input data for simulation analysis [2,4,8,10].

Statistical models of the system work cycles are mathematical expressions that stochasticly explain how random variables behave in a given space. Therefore, stochastic models are used in simulations for generating random variables that explain the behavior of the actual system in certain operating conditions. In our case, we will use the data collected through the informational system of the Ugljevik coal mine through the 2015.
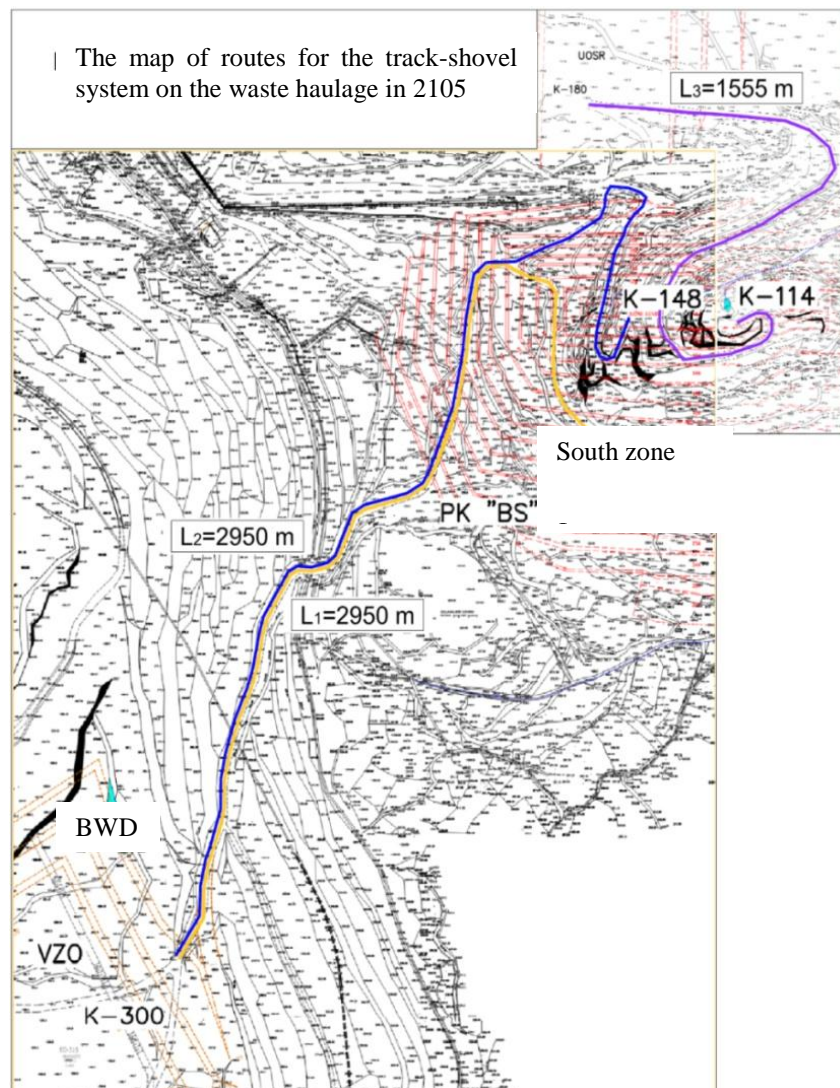

Figure 2. Scheme of transportation of Shovel-truck system on the waste in 2015 year

Generating of characteristic random processes for the real system in a discontinuous transport system model is based on the technical and technological parameters of the considered equipment by the parameters obtained within statistical analysis and the data of time recording about certain activities

duration in the transport and loading cycle. The loading time of one excavator bucket is calculated in the function of the stochastic duration of individual excavator operations time cycles in the real work environment characteristics. In Table 1, we have adopted the functions of allocating the time of the excavator activities with the necessary parameters for Talpac simulation software.

Table 1. Adjusted parameters of the distribution of excavators time activities

Activity	Distribution	Distribution with Parameters
PC 3000 – loading time for truck	Gamma	60*(0.9600+RVGAMA(str.,0.69219,58.8339))
RH 120 - loading time for truck	Gamma	60*(2.84706+RVGAMA(str.,0.63534,30.2740))

Reliability time and cancellation time of the shovel are generated by Gamma and Weibull distribution, and are determined according to samples of registered data in the mine management system (Table 2)

Table 2. Adopted parameters of the failure allocation for the excavator

Activity	Distribution	Distribution with Parameters
Reliability time for shovelPC 3000	Gamma	60*(0.9600+RVGAMA(str.,0.69219,58.8339))
Reliability time for shovelRH 120	Gamma	60*(2.84706+RVGAMA(str.,0.63534,30.2740))
Reliability time for shovelPC 3000	Weibull	60*(3.9954 +RVWEIB(str.,0.87350,15.6302))
Reliability time for shovelRH 120	Weibull	60*(0.88925 +RVWEIB(str.,0.62672,14.7694))

Reliability time parameters of the trucks for the generation of cancellation and reliability time are given in Table 3. It is necessary to emphasize that the same distribution of cancellation and reliability time has been adopted for all three trucks types due to the lack of data on new units that are not currently operating on the open pit and due to technically more equitable comparison of alternative combinations.

Table 3. Adopted parameter for the trucks cancellation time distribution

Activity	Distribution	Distribution with Parameters
Reliability time for truck Bellaz	Gamma	60*(7.9235+RVGAMA(str.,0.42938, 184.197))
Reliability time for truck Bellaz	Weibull	60*(2.9931+RVWEIB(str.,0 .90356, 13.6224))

The average speeds of the full and empty trucks are generated by a normal distribution based on data from the Mine system for the adopted haulage roads structure by the operation phases. The haulage roads were obtained by linking the center of mass on the working benches with the landfill locations, and for each road section the necessary elements for simulation (length, inclination, breaking resistance, etc.) were defined, Figure 2.

Simulation analysis - The simulation model includes the frames of real processes in the system starting from shovel digging and loading, full trucks motion to the unloading site and returning trucks from the unloading site to the shovel [2,6,8,10]. Of course, in the model it was not possible to include all the details that appeared in real conditions of the transport system operation, but by the model validation and verification with the collected data using the mentioned software, the desired accuracy of the simulation results was obtained in this case study.

In any case, the simulation model, built on the basis of collected in real-time conditions and time data processed by statistical and stochastic models, reflects dynamically in the specific time and space the state of the haulage system on the waste exploitation. The flexibility of the model is reflected in the possibility of considering different equipment structures in the system and optimizing the parameters of individual processes in the system as well as a specific transport system.In this case study, the simultaneous work of three discontinuous reverse detection systems was considered, allowing the improving possibility the efficiency of the shovel-trucks system operation. The baseline for system analysis is the definition of combinations of loading and haulage equipment in 2015, which are the following systems:

System 1:   Shovel PC 3000 (15 m^3) / Trucks Belaz 75135 (130t, 6 pieces),
System 2:   Shovel PC 3000 (15 m^3) / Trucks Belaz 75135 (130t, 6 pieces),
System 3:   Shovel RH 120 (12 m^3) / Trucks Belaz 75135 (130t, 4 pieces).

These three systems had worked in a fixed cycle (mode) by each shovel was working with the assigned number of trucks. This operation mode of the system is a basic system for comparison with the dynamic cycle of truck operation. The "dispatching mode" means an open cycle for all trucks in the system, so that in each subsequent cycle the truck can be loaded with any shovel [2,6,8].A comparative simulation results overview with statistics for different dispatch criteria is shown in Table 4. Here, the FCK represents a fixed cycle of trucks, that is, a base operating system version in 2015 with which we compare possible variants of the operation of the discounted systems. In addition, two modes were analyzed - minimization of the truck cycle duration - *MTCK* and the minimization of the shovel waiting time - *MVČB* .

As expected, the simulation results show that the curve of the simulated production, in function of the number of trucks, has the same characteristics as the system production curve in 2015, Figure 3. The system production capacity is constantly increasing with the increase in the number of trucks in the system to the point of saturation of the system , where the curve begins with a slight fall. At this moment, shovels work with maximum utilization, which makes them no more growth in capacity regardless of the addition of trucks to the system. It is also interesting to note that the curves of the simulated capacities are always below the ideal or the maximum theoretical capacity of the system. This particularly emphasizes the validity of the logic applied in the simulation model.

Both additional considered criteria increased the production of the shovel -truck system. However,

since the simulation is a stochastic experiment, it is necessary to statistically establish the validity of these increases. Therefore, the fixed system is used as the base system, and all other systems are compared with it to determine statistically significant increases in production. Figure 4 shows the percentage difference in production in comparison with the fixed (closed work cycle).

Table 4. Comparative presentation of simulation parameters for different dispatch criteria

Number of trucks in operation	Dispatch criterion	Simulated production t/year	increase in production %	Shovel capacity, t/year		
				Shovel 1	Shovel 2	Shovel 3
14	FCK	4436366		1676010	1761360	998996
	MTCK	4539691	1.0233	1707855	1801871	1029965
	MVČB	4529701	1.0210	1707855	1801871	1019975
15	FCK	4528023		1710637	1797750	1019636
	MTCK	4636695	1.0240	1751693	1840896	1044107
	MVČB	4613603	1.0189	1742968	1831727	1038907
16	FCK	4605862		1740044	1828654	1037164
	MTCK	4739023	1.0289	1804426	1872542	1062056
	MVČB	4714254	1.0235	1793985	1863398	1056870
17	FCK	4705809		1777803	1868336	1059670
	MTCK	4943327	1.0505	1871849	1959884	1111594
	MVČB	4909138	1.0432	1855493	1959324	1094322
18	FCK	4744038		1792245	1883514	1068279
	MTCK	4957520	1.0450	1872896	1968272	1116351
	MVČB	4901118	1.0331	1846013	1949437	1105669
19	FCK	4719166		1782849	1873639	1062678
	MTCK	4878202	1.0337	1842931	1936781	1098490
	MVČB	4867820	1.0315	1839009	1932659	1096153
20	FCK	4697979		1774845	1865227	1057907
	MTCK	4837979	1.0298	1827735	1920811	1089433
	MVČB	4824825	1.0270	1822766	1915588	1086471

It's noticeable in the analyzed dispatching algorithms, they have a proper effect on the system production increasing, but the percentage of increase is in the function of saturation of the system by trucks. Both of these criteria achieve better efficiency if the number of trucks in the system is in the optimal range, 17 to 18 in this case. The percentage increase is constantly increasing to the optimal number of trucks in the system, which occurs around 17 trucks, where the rapid decline begins in the percentage increase for all systems. If the system is unsaturated or overloaded with trucks, the

percentage of increase in production is almost the same for all algorithms. Therefore, an analysis of the effects of the dispatch criteria should be carried out for each dispatch system for the full range of trucks in the system from unsaturated to saturated.
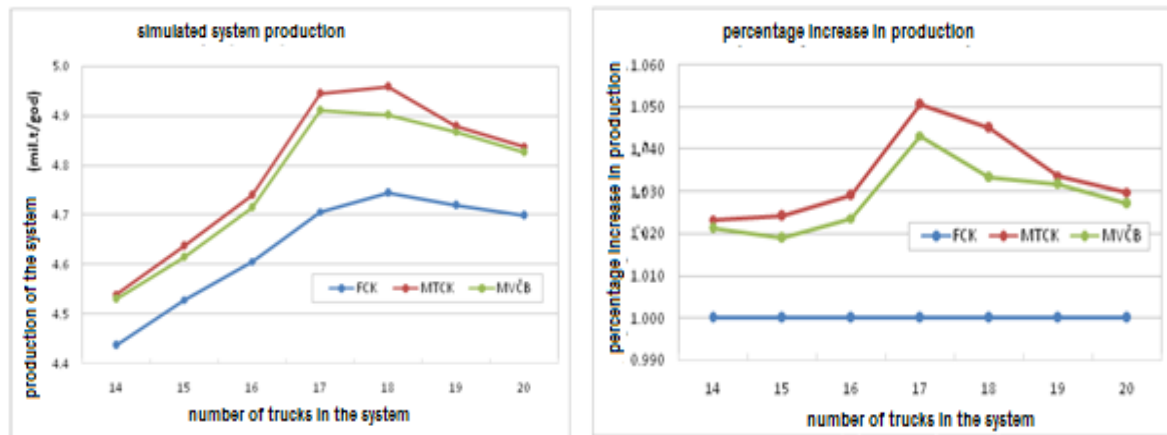

Figure3.Comparative overview of capacity
Figure 4. Percentage capacity growth in relation simulationto the System

In the case of *MVČB* in relation to the *MTCK* criterion, the results show that the remote shovels will be constantly less used (Figures 3 and 4), and the differences in the waiting times of shovels are more pronounced for systems with fewer trucks. This is explained by the fact that the *MTCK* criterion send trucks to shovels where they can be fastest loaded with the shortest cycle of trucks, which means that shovels with longer cycles will accumulate more waiting time. The shovel waiting time is proportional to the haulage length in the case of the *MTCK* criteria.

The *MVČB* criterion tends to distribute the waiting time uniformly among all excavators because the trucks are alternatively distributed by shovels, which generally generates a minor increase in production by this criterion. With the increase in the number of trucks in the system (Figure 3), the efficiency of these criterias decreases as the shovel waiting time becomes insignificant, so shovels work with maximum performance. Consequently, there is no increase in production with the addition of trucks to the system when the system goes into the condition of saturation with trucks, and we can conclude, for this case of analysis, that the *MTCK* algorithm can achieve superior quantitative results in production, achieving a higher production of over 5% compared to the *FCK*. The case study in this paper has shown that the considered algorithms can contribute to the optimization of discontinuous exploitation systems in concrete working conditions [2,4,5,6,8]. In the case of analysis using the *MTCK* algorithm, the results showed that a significantly more efficient system operation can be achieved. This criterion uses closer shovls so that the waiting time is proportional to the haulage distance length of the truck. The difference in the shovel waiting time is more pronounced with a smaller number of trucks in the system.

This can be explained by the fact that this criterion distributes the truck to the shovel where it will most likely be loaded, which causes the trucks distribution to the nearest shovels, because only in that case the truck exceeds the shortest length,and it achieves the shortest cycle.In the case of the *MVČB* algorithm, the shovel waiting time is minimized, and the production capacity is maximized. The prediction of this criterion is that the shovel waiting time is distributed among all sovels, since trucks will alternatively be distributed by shovels. This procedure allows almost equal use of all shovels. It should be noted here that the difference was in capacity or waiting time only due to different driving times.

CONCLUSION

The motivation and goal of the research in improving the organization and management of loading and haulage equipment on the open pits are the facts that traffic is a phenomenon with negative effects

in its parent process and that in mining haulage also has an impact through the fact that mines constantly grow in the size and scope of production/capacity. On this way defining the size of the fleet, and thus the volume of traffic are with a great importance. Any improvement in the coordination

and management of the loading and haulage equipment system will ultimately lead to higher productivity, revenue increasing with a reduction in costs.

An obvious need for better control, new information and communication technologies, and knowledge management needed to get value from the information date has focused attention on tactical management. Developing a management model for all open pit mines is not feasible, since culture, working conditions and processes are unique for almost every mine. The application and success of the management model depends on the development of the management system in parallel with the mining system. The logic of the methodology is organized in two basic units: logistical-informational (with three phases of development) and operational-simulation (with one phase and two sub-phases of model development).   .

The development phases of the logistics information system unit are composed of: planning and building the system infrastructure, determining measures - the way of valuation and performance, and building of management infrastructure.Operational-simulation system unit is developing an operational phase-dispatching process, dealing with issues related to the way of use, maintenance and future development of the management system (collection and statistical processing of data, and use of the simulation model).   .

As a rule, management systems evolve over time, especially when it comes to changes in the management system. Some of them have been applied successfully, and some have failed. Difficulties in the application of these techniques are the consequence of the differences between the industrial branches in which they originated and the mining industry, which is stated above. Therefore, it was necessary to make appropriate analyzes and to determine the specificities of mining, as well as the requirements that modeling techniques should fulfill in this branch of industry.

LITERATURE

[1]   Alarie, S. &Gamache, M. (2002). Overview of solution strategies used in truck dispatching systems for open pit mine', International Journal of Surface Mining, Reclamation and Environment 16(1), 59-76.
[2]   Kolonja, B., Vasiljevic, N. (2000). Computer Simulation of Open-Pit Transportation Systems, MinPlanning and Equipment SelectionPanagiotou and Michalakopoulos (Eds), Balkema, Rotterdam, pp. 613-618.
[3]   Drebenstedt, C. (2013). The Responsible Mining Concept, Proceedings of the 22nd MPES Conference, Dresden, Germany, pp 3-22.
[4]   Panagiotou, G. ,Michalakopoulos, T. eds. (2000). Mine planning and equipment selection , Proceedings of the Ninth International Symposium on Mine Planning and Equipment Selection, A.A. Balkema, Rotterdam, 547–553.
[5]   White, J., Arnold, M.J., Clavenger, J.G. (1982). Automated Open-Pit Truck Dispatching at Tyrone,Engineering & Mining Journal, vol. 183, no. 6, pp. 76-84.
[6]   Çetin, N. (2004). Open pit truck / shovel haulage system simulation.Ph.Dthesis., The Graduate School of Natural and Applied Sciences of the Middle East Technical University- Department of Mining Engineering, 116 pages.
[7]   Burt, C. N. &Caccetta, L. (2007), Match factor for heterogeneous truck and loader fleets', International journal of mining, reclamation and environment 21, pp. 262-270.
[8]   Milošević, D. (2018). A model of management of discontinuous exploitation systems on surface mines. Doctoral dissertation. University of Banja Luka, Faculty of Mining Prijedor. Bosnia and Herzegovina.
[9]   Belyakov, N. (2013).Modeling Development of Deep Horizons of Open Pits, Proceedings of the 22nd MPES Conference, Dresden, Germany, pp 43-51.
[10]   Malbašić, V. (2007): Model for evaluation of transport systems in the function of long-term planning of surface mines. Doctoral dissertation, University of Belgrade, RGFBelgrade.

[11]   Krause, A. &Musingwini, C.(2007).„Modelling open pit shovel-truck systems using the Machine Repair Model", Journal of the Southern African Institute of Mining and Metallurgy, Volume 107, Number 8 pp. 469-476.

[12]   Liu, J., Bongaerts,J.C.   (2014).Mine Planning and Equipment Selection Supply Chain of Rare EarthElements (REEs), Proceedins Mine Planning and Equipment Selectionpp 1419-1426.

 [13]   A.M. Newman, A.M.., Rubio, E.,Caro, R.,Weintraub, A.,Eurek, E. (2010).A Review of Operations Research in Mine Planning, INFORMS Journal on Applied AnalyticsVol. 40, No. 3,https://doi.org/10.1287/inte.1090.0492.