Minimization of Coal Mining Machines Downtime in Coal Mining by Opened-Underground Mining Method on Simulating Model

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Abstract. Discrete-and-stochastic simulation model has been developed. The model displays in time and space the interaction between elements of excavating machines complex and deep mining seams complex. Program realization of the model has been created in GPSS Studio simulating modeling tool. The influence of offers for minimization of unplanned downtime of mining machines on daily volume of mined coal by opened-and-underground method has been researched in simulation experiments.

1 Introduction

There is a mixed method of mining (opened-and-underground) except classic methods of coal mining like opened and underground methods. The method is based on use of deep elaboration seam complex (DESC) and cave-auto complex (CAC). In this way DESC is situated on wide part of mine. Mining process is carried out by continuous shaving of coal with a combine with use of a special device. The effect is achieved through using of existing infrastructure of coal mine. The unnecessary conduct of expensive underground mining and stripping. At the same time, high safety of industry is provided due to the absence of minders in mining face and no burst mining [1-8]. There are systems of transport automatization: VIST, Mining Technology, Caterpillar, Komatsu, Remota control technologies, Cavotec, Specto Remote, Dynamic Automation Systems, Modelar mining system, etc [9-15]. There is an experience of use of unmanned technology with application of DECS. The systems and equipment allow to create opened-and-underground technologies with not constant people presence. It provides increasing of mining efficiency and mining safety. The efficiency of interaction between DESC and CAC depends of a structure and parameters of used machines, planned and unplanned downtime. Planned downtime is calculated in project documents for each conditions of used mining machines. It includes: an addiction of a high-voltage cable, preventive maintenance, way cleaning by

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bulldozer, refueling, drilling and blasting, mining faces preparing, maintenance, etc. Such downtime is calculated on the stage of planning and projecting of mining works.

It's much more difficult to calculate unplanned downtime, because they are accidental and come because of repairing or replacing of parts of mining machines, bad organization, climate conditions or another force Majeure. These downtime can achieve take up a significant part of work time and as result conduct to reduction of mine efficiency. A calculation and minimization of downtime are required for choice of parameters of opened-and-underground geo-technology. For the research of geo-technologies they use methods and computer models, which allow to carry out calculations and optimize the schedule on seam mining by opened and opened-and-underground methods. At the same time, the interaction between mining machines in dynamics is not shown at models, but the influence of planned downtime is defined only. Possible downtime is fixed as timing of year or half-year period of mining work, then the difference between planned and real volume is analysed. And loss, which have taken place before, will never be replenished. Modern methods and programming remedies of simulating modeling allow to show the interaction between DESC and CAC with attention to possible downtime of mining machines, to analyse their influence for development of opened-and-underground geo-technology.

2 Experimental

2.1. Conceptual discrete-stochastic dynamic model in the form of Queuing systems

For displaying various complex systems in dynamics with consideration of random factors, including in mining, the approach using the theory of Queuing systems and simulation modeling using the GPSS language in various versions has proven itself well. Using the elements of the Queuing systems, a conceptual discrete-stochastic dynamic model was developed that reflects the interaction of the CAC and the DESC, taking into account the probabilistic downtime of mining machines, fig. 1.

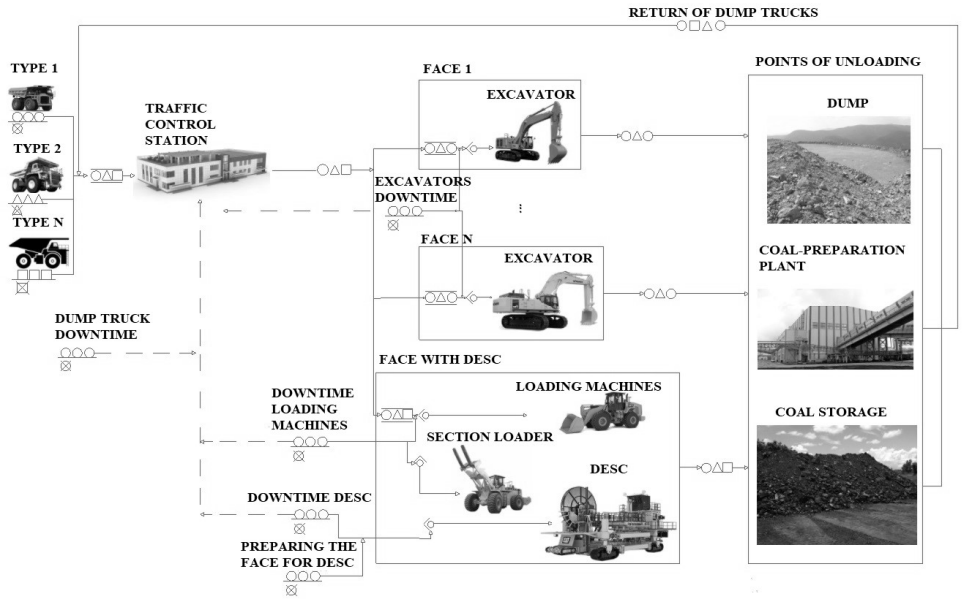

Fig. 1. Conceptual discrete-stochastic dynamic model in the form of a Queuing system.

The system includes two types of request sources. The first type of sources forms a certain number of requests corresponding to the number of dump trucks of a given load capacity. These requests are sent to the service device «Traffic control station», where they are redistributed along the faces in accordance with the dispatcher's decision. The service devices «Excavator» and «Loading machines» delay each request for a time equal to the time of loading the rock mass into a dump truck. After this time, requests are received for service in the devices that display the warehouse, dump, and processing plant, displaying the process of loading the rock mass. After that, applications simulating empty dump trucks are returned to the traffic control station for further redistribution. The second type of source is intended for modeling downtime of mining machines. These sources generate requests at probabilistic time intervals, which close peculiar valves and restrict the access of dump truck requests to the corresponding service device. Also, when generating such a request, a signal is sent to the traffic control station, which redistributes dump truck requests between the faces, taking into account the downtime of the corresponding service device.

2.2. Software implementation

In GPSS Studio (JSC "Ellina-Computer", Russia), the simulating model based for conceptual model has been created. It allows to show the dynamics of interaction between CAC and DESC, and to pay attention to possible downtime of mining machines, fig. 2.

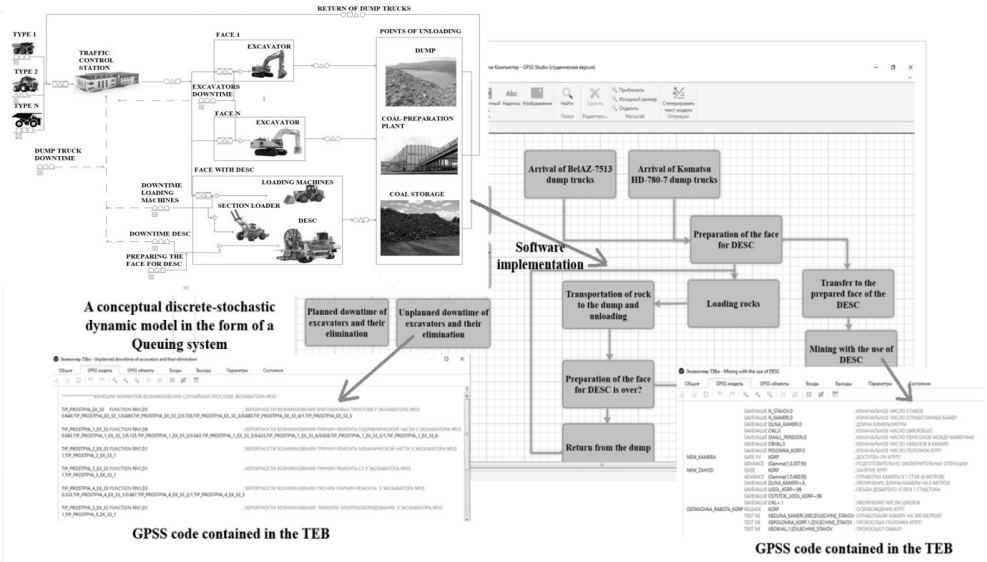

Fig. 2. Computer implementation of model of interaction between CAC and DESC in GPSS Studio.

The model consists of interacted typical elementary blocks (TEB). «TEBs» show technological processes, keep duration data of operations and mining machines downtime. There is a group of blocks of GPSS World model, which simulate technological operations, in each TEB. For example, there are blocks SEIZE, ADVANCE, RELEASE in TEB «Excavator loading». They show operations of rock mass loading in machines.

To verify the adequacy of the developed model, we used the data of timing measurements of dispatch reports of motor convoys of Kuzbass sections: mined rock mass volume, the number of trips of dump trucks, an average duration of loading of rock mass with an excavator in dump trucks, mining machines use, daily mining volume, the number

of drillings with use of DESC, the number of cycles for one drill. The deviation between the data and modeling results was not more than 9%.

3 Results and discussion

In simulating experiment we can evaluate mining process of parts and all coal pit in general. Also we can analyse: the degree of excavators use, current, average, maximal size of dump trucks line for loading or unloading, average and maximal time of presence of dump trucks in line. Fig. 2 and 3 show some experimental results of experiments of evaluating of daily production from two different mining faces with attention to mining machines downtime.

The dashed line shows planned production of mining face, solid line – production with attention to possible unplanned downtime of technical and organizational nature. We can see, that planned production is different with production included unplanned downtime – «non-production periods» take place. On fig. 3, in period (A), downtime took place during 44-46 days because of replacing hydro-cylinder for lifting of working part and hydraulic motor of excavator, dump trucks wheel service, hydraulic suspension repairing, cooling and repair of the hydraulic system of dump trucks. In period B, 98-100 days the engine repairing took place, replacing of high pressure hose, repairing of hydro-working part of excavator, wheel service, hydro-suspension repairing, dump truck control system. Downtime in period (C), 176-178 days took place because of replace of hydro-cylinder of working part, hydraulic engine repairing and hydraulic system repairing, suspension, electrical equipment, wheel service. On fig. 4 in periods (A), 12-19 days and (F), 63-67 days downtime took places because of excavator stuck, in periods (B), (C), (D) – because of luck of diesel fuel, add period (E) - excavator mechanical parts repair. As result, the deviation between planned volume of year period with attention to unplanned downtime for mining face with HITACHI EX-2500 was 16,7%, with Volvo EC-480 - 16, 9%.

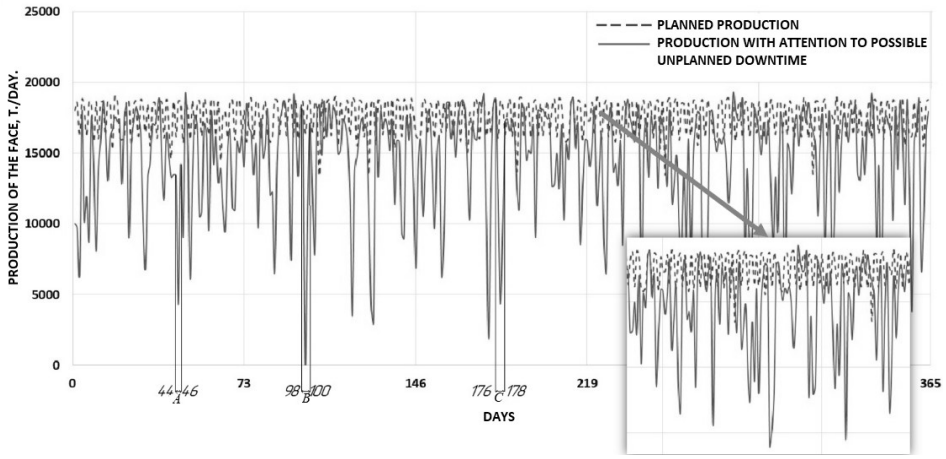

Fig. 3. Mining face with HITACHI EX-2500 volume.

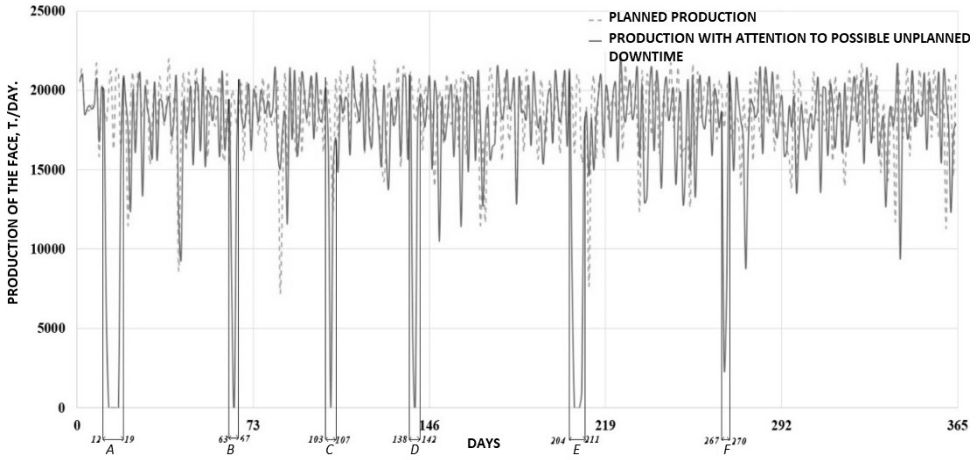

Fig. 4. Mining face with Volvo EC-480 volume.

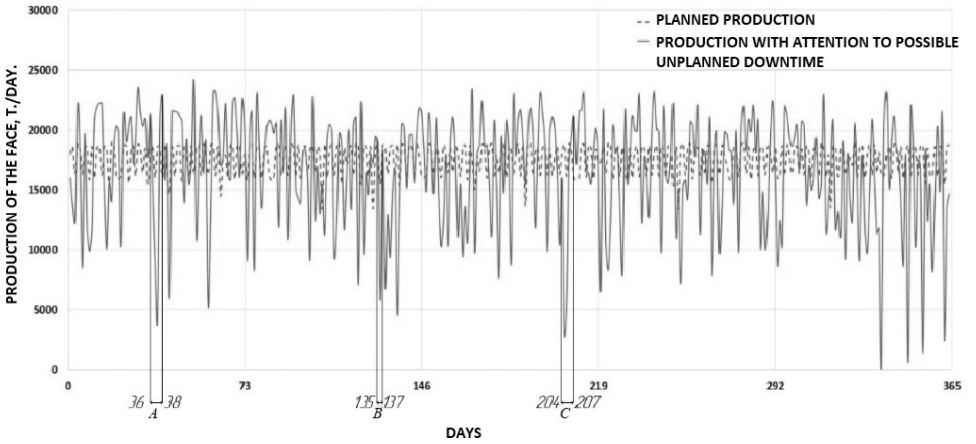

Fig. 5. Mining face with HITACHI EX-2500 volume with an organization of an excavator work on two ways.

It's been defined, that an organization of an excavator work on two ways will allow to reduce the deviation between planned mining face volume and volume of mining face with not planned downtime on 11,7%. At this time, production of a mining face will be increased on 5,4%, fig 5.

For the minimization of downtime in mining face with the excavator Volvo EC-480 the extra volume of diesel fuel has been given, fig 6.

It's been defined, that extra 5000 tons of diesel fuel will provide an opportunity of reduction of the deviation between planned production of mining face with unplanned downtime presence production on 5,9%.

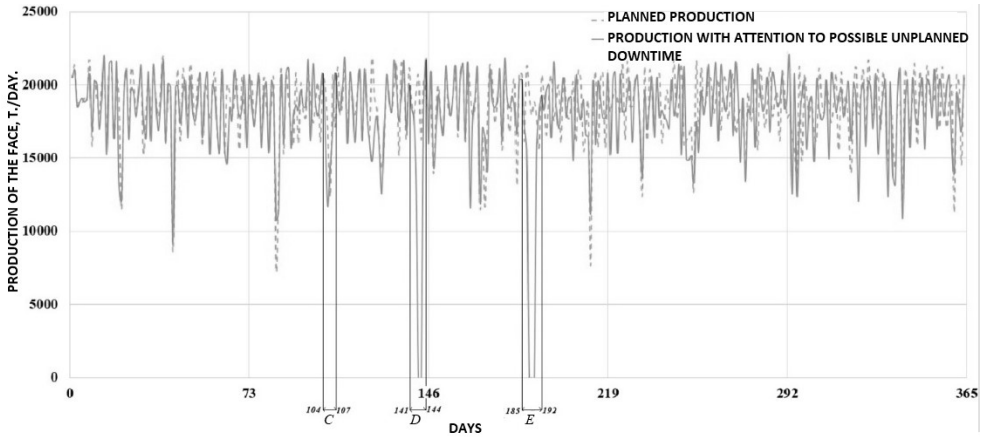

Fig. 6. Mining face with Volvo EC-480 volume with extra fuel.

4 Conclusions

Thus, simulating modeling of the interaction of automated complex of deep seams production will allow to research the influence of unplanned possible downtime of mining machines on the volume on coal mining with opened-and-underground method, to evaluate unplanned offers how to minimalize it and to except losses of coal before the start of mining works.

Acknowledgement

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