

SIMULATION SYSTEM OF MINING WORKS

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ABSTRACT

Information system for simulating of tunneling works, which was engineered by the Federal Research Center of Coal and Coal-Chemistry of Siberian Branch of the Russian Academy of Sciences (FRC CCC SB RAS), is shown in the article. The system is a supporting tool for making decisions in tunneling works projection and efficiency evaluation. After selection of geological factors, user gets list of appropriate equipment. The technology will be formed with using of this equipment. System chic is automatic creation of simulating models of tunneling works from simulating modules of technology elements, which were developed with use of special language GPSS World. Moreover, there were automatizations of processes of models start, getting results of simulating, creation of report-file with technical and economical characteristics and tunneling works schedule. Using of the system in part of carrying experiments allows finding ways for increasing of efficiency detect bottleneck and find solutions how to eliminate bottleneck, make evaluation of efficiency of mine technical systems and find ways of efficiency increasing.

Keywords: simulation, mine technical systems, CAD, decision support system

1. INTRODUCTION

Process of complex familiarization and learning of coal fields contains the next actual headings:

- Innovate technologies of familiarization and learning of coal fields systems analysis and substantiation;
- Design and development of software tools, methods and approaches for modeling of innovative technologies and complex familiarization development;
- Developing of methods and algorithms of prediction, evaluation of trustworthiness and efficiency mine-engineering system.

Accumulated experience shows that efficient tool for decision supporting for planning new high-efficient different industrial areas is simulating which displays system dynamics in PC by algorithm, which simulates system's behavior (Konyukh V. 2010; Oparin V.N. 2007; Andrei A. and Dinescu S. 2013; Hubalovsky S. 2014; Guizzi G., Murino T. and Romano E. 2009; Kleinrock L. 1979; Starodubov A.N. 2013; Sinoviev V.V., Starodubov A.N., Majorov A.E. and Kochetkov V.N. 2013; Poletayev V.A., Sinoviev V.V., Starodubov A.N. and Chicherin I.V. 2011).

2. MATERIALS

There are innovate system creation projects in Institute of Coal FRC CCC SB RAS for tunneling works simulation. Modern computer simulation language GPSS World was chosen as software implementation models tool for complex industrial systems simulating (Sinoviev V.V. 2013; Lou A.M. and Kelton A.D. 2004; Devytkov V.V. 2013; Okolnishnikov V., Rudometov S., and Zhuravlev S. 2010; Starodubov A.N., Sinoviev V.V. and Dorofeev M.U. 2010; Sinoviev V.V., Okolnishnikov V.V., Starodubov A.N. and Dorofeev M.U. 2015). The system designed on base of machine code C#4 in Microsoft Visual Studio 2012. Projects and templates is in "xml" format. Simulation model storage is in "gps" format. Information system allows analyzing the next list of tunneling works design elements:

- Equipment choice and selection of technological scheme of works;
- Simulation model building and simulating experiment leading;
- Statistical data accumulating;
- Visual display of tunnel works dynamics developing;
- Organizational works schedule;
- Technical and economic indicators calculation.

Figure 1 presents a scheme of options for using of informative tunnel works simulation model elements.

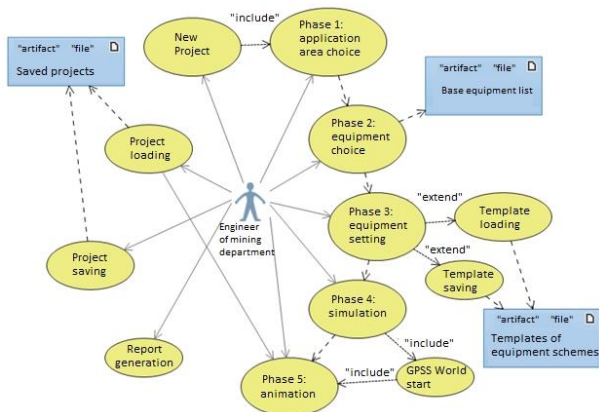


Figure 1: Diagram of options for using of informative system elements

User creates new project and choose geological factors. The next step is automatic formation of appropriate mining machines from database. User creates set of equipment from this list. User is able to correct characteristics if necessary. There is an opportunity of choice of prepared template and user is able to create new template and save it. Generation models module takes signal by button push for launching. This module forms a mine-works variant from library. The imitation module launches model and shows the result of simulation experiment. Technology animation and report files are formed automatically. There are main technical and economic indicators and tunneling works planogram in report files. User is able to save project of developed technology for modification and using in near future.

Simulation modeling system functioning is shown by example of underground drilling scheme with using of cutter-loader with attached implements and belt loader (Figure 2).

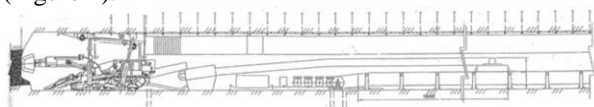


Figure 2: Technological scheme of underground drilling with using of cutter-loader (with attached implements and belt loader)

There are these works inside mining face: cross drift, engineering complex moving, belt loader enragement, rail way enlargement, pump tree enlargement, belt loader and re-loader technical service, rig two-way delivering, sinking, water pressing-in, rig work, barring, pipes and wires moving, materials delivering.

At the first stage of working with simulation system you should enter the next items: size in the clear, mine working angle of slope, amount of inclination, toughness coefficient, vertical conformance, thickness of a steam (Figure 3).

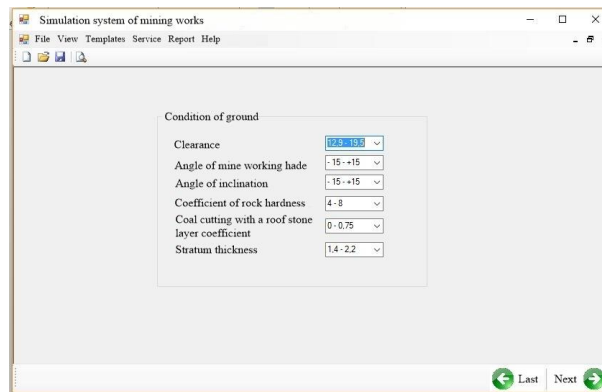


Figure 3: Geological factors selection

Transition to the next stage is due to button "NEXT". User will select equipment from list "Initial equipment" and will add it in list "Selected equipment" (Figure 4).

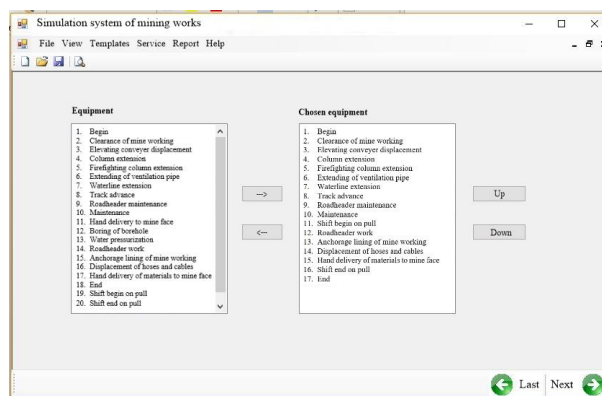


Figure 4: Equipment selection

On the next stage user will select necessary works, which will be done due to special equipment. User has to enter random duration for each work and number of workers (Figure 5).

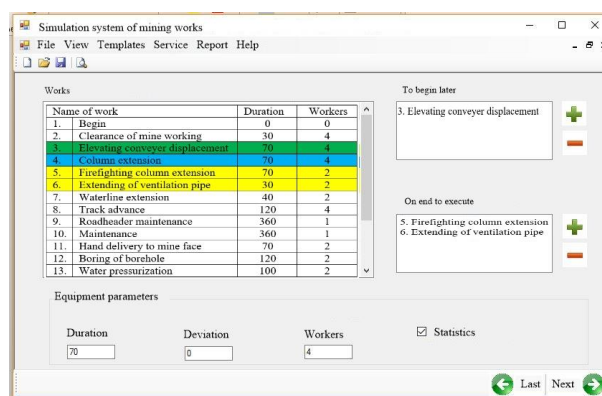


Figure 5: Works selection

User launches generation of model by prepared options, defines options, and makes simulation start (Figure 6).

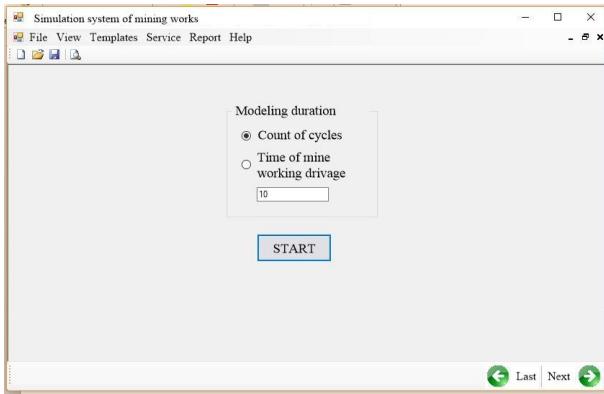


Figure 6: Simulation parameters setting

GPSS World model of developed scheme was based on the next approach. It is defined that requests for execution of works are equal with simulation model transactions. Block GENATATE was created for input to the model. Instruments in the model are works and mining equipment, which described by raw of blocks SEIZE-RELEASE and ENTER-LEAVE (for displaying of both work equipment). To model the duration of operations was used ADVANCE blocks, which delay transacts at time of execution of technological operations. TERMITATE block is created for deleting of transacts after end of the modeling. According to technological schemes, functioning of various equipment can be carried out at the same time. SPLIT block was created for separation. Block ASSIMBLE is for synchronizing of concurrent tasks. LOOP blocks are for simulation of technological operations (to the beginning of the cycle) and ASSIGN block (to specify the number of repetitions, which are stored in the parameter transact).

Model consists of the following components:

- Initialization of the model
- Performed works
- Finalization of the model
- Collecting of statistical data

During initialization of the model in GENERATE block occurs the appearance of the one transact. This transact will exist during the all simulation time and simulation will be completed after destruction of transact. Transact parameter is written in the number of full cycles (days) of simulation in the ASSIGN block. Next is a pointer to the beginning of the change of the care and synchronization transact in block ASSEMBLE. ASSIGN command is for input the number of care cycles. SPLIT block simulates beginning of parallel works. TRNSFER command moves in block, which simulates the first technological operation beginning (Figure 7).

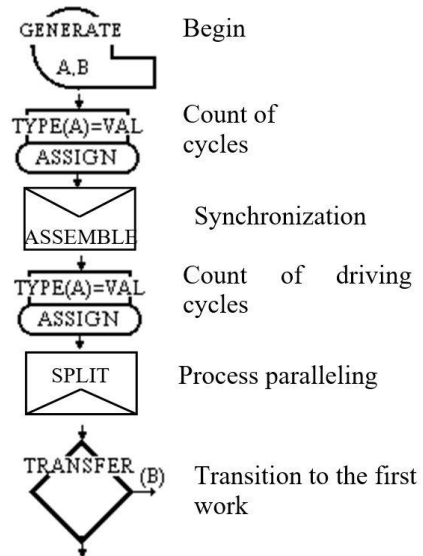


Figure 7: Model initialization flow chart

Model initialization code will be:

	GENERATE	0,,1
	ASSIGN	2,1
START1	ASSEMBLE	1
	ASSIGN	3,9
	SPLIT	1,WORK2
	TRANSFER	,WORK11

There is inspection of task, transact equality to zero (responsible for the number of simulated cycles) after all works for finalization of the model. If the parameter is zero then there is a moving to the next block TERMINATE, which removes transact and ends simulation. If the parameter is not equal to zero then number reduced by one and there is moving to beginning of the model.

Figure 8 shows the scheme of model finalization.

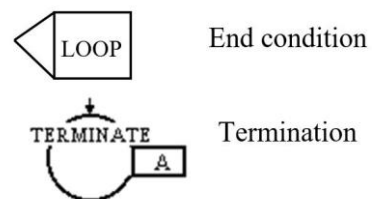


Figure 8: Scheme of model finalization

Model finalization code will be:

	LOOP	2,START1
	TERMINATE	1

Construction of work models in this way allows you to generate technological model entirely. After START button system receives process and operations GPSS World-codes from data base, which were set up by user on the works selection stage (pic 5), in addition there are reading of models parameters (temporary delays, deviation, necessity of statistical data for this operation) and formation of model of technology in appliance with indicated order of executed operations. System uses this

data to arrange size of operand in blocks SPLIT and ASSEMBLE. It is dividing of operations or ban of synchronous operations execution. Model is supplemented by initialization and finalization blocks, which have been mentioned above. The next step is moving of generated model for start in simulation environment.

Animation of scraper-works (Figure 9) and report documents with experimental results in MS Excel format will be formed after simulating ending. There are two tables with report data: technical and economic parameters for the selected scheme and schedule of works. Technical and economical parameters (Figure 10) consist of information about speed of elaboration leading with chosen technology on different time periods. For example, the number of passed meters for one day-shift, day or month. In addition, there are data in tables for mine works planning: working days number, the number and duration of shifts in day, cycles in shift and the required number of service staff.

On the schedule of works graph (Figure 11) you can see order and time of sinking cycle execution, order and combination of processes in mining face.

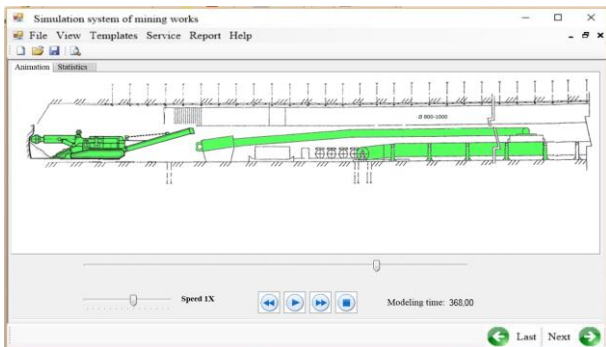


Figure 9: Tunnel works animation

Animation allows switch frames forward and backward stepwise, change positions of shown elements of control, animation speed, monitoring of the current time of technological operations. Functioning equipment is green, equipment, which is in service - yellow.

There are principal technical and economical characteristics of technology and tunnel works planogram in report file.

Technical and economical characteristics			
No	Characteristics		
1	Speed of mine working drive		
	m/month		540
	m/day		18,00
	m/shift		6,00
2	Face advance on cycle, m		2,00
3	Count of cycles		
	in shift		3,00
	in days		9
4	Count of working days in month		30
5	Count of shifts in day		4
6	Shift duration, h		6
7	Cycle duration, min.		120
8	Workers count		
	in shift		4
	on pull		8

Figure 10: Technical and economical characteristics for chosen scheme

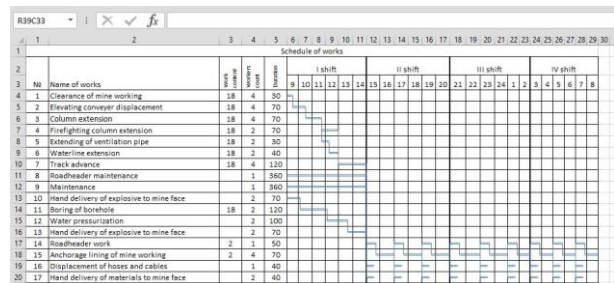


Figure 11: Schedule of works

The proposed system allows through leading of simulation experiments to define ways of increasing of productivity, to identify bottleneck and find solutions how to eliminate bottleneck, to assess the effectiveness of mine technical systems and ways of its increase. For example, experiments were conducted to identify the effectiveness of proposals for robotics of combine technology. Row of experiments on models of the original technology and modified technology after applying of robotics is performed. Histogram showing the influence of tram on degree of use cutter-loader in basic and robotic technologies is shown on Figure 12. Determined that the degree of use of cutter-loader in robotic mining technology increases to 22-50% (depends of tram capacity) compared to the conventional technology.

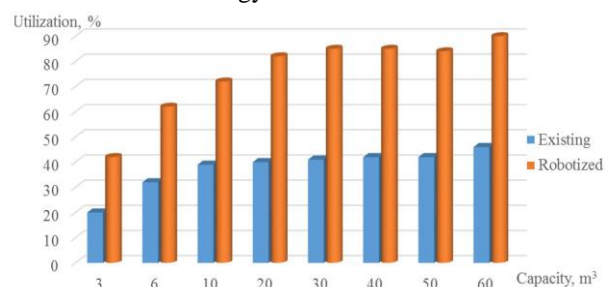


Figure 12: Impact of transport capacity on the combine utilization

3. RESULTS

As result, there are information system, which allows automatically to select equipment for given geological factors, to build simulation models of scraper works leading, to show dynamic of scraper woks leading on PC monitor, to collect statistical data about main technical and economical parameters, to build schedule works graph.

User enters geological factors into the information system. System forms list of the equipment. Simulated models will be created automatically from standard ready-made GPSS World modules, which shows the most important technological processes. On the next stage system launches models, obtains results and shows statistical data about simulating results in special report-file. Finally, a graph of scraper works schedule and the main technical and economic indicators will be shown on PC screen.

Use of the system will speed up and improve the process of designing a solid mining technology, and eliminate costly technological risks by automating the calculation of technical and institutional options of conducting mining operations. Moreover, this system can serve as a tool to support decision-making in determining ways to improve efficiency, identify and eliminate bottleneck in the technology and assess the effectiveness of mine technical system. Coal mine is a complicated technological object, so the establishment of such information systems is an important step in the development and transfer of the coal industry to the higher technological level.

ACKNOWLEDGMENTS

This research was financially supported by the Russian Foundation for Basic Research (project 16-47-420490 p_a).

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