Research of draw mining method modes using simulation model

A N Starodubov\textsuperscript{1,2}, V V Sinoviev\textsuperscript{1,2} and V I Klishin\textsuperscript{1,2}

\textsuperscript{1}Institute of Coal, Federal Research Center for Coal and Coal Chemistry, Siberian Branch of Russian Academy of Sciences, 10 Leningradsky pr., Kemerovo, 650065, Russia
\textsuperscript{2}T. F. Gorbachev Kuzbass State Technical University, 28 Vesennyaya str., Kemerovo, 650000, Russia

E-mail: a.n.starodubov@gmail.com

Abstract: A simulation model of effective coal fields operation by robotized system with controlled draw mining method. The developed model shown by animation for visual displaying of robotized system and results of simulation. We gave a valuation of technology, rational parameters for more efficient use of equipment. Research of draw mining method coal (individual, waved, group, areal) modes has been carried out with using of developed resources.

1. Introduction
Significant part of world stocks of high-grade coal is concentrated at thick seams (more than 5m). The method of underground operation of such seams using long breakage faces is the most efficient nowadays. The most effective and safety technology of thick seams operation is their all-volume excavation from sublevel caving and thickness between layers. Coal institute of FRC CCC SB RAS developed a new project of mechanized support with controlled draw mining. The construction is based on use of feeders with regulated productive properties at support sections. The feeders are installed at special places in supporting part – this provides a controlled sublevel caving on all longwall length [5-7].

The control of draw mining is based on successively opening of entering windows in borders of section-type support (figure 1).

Draw mining can be made at different modes (schemes at figure 2):
- individual: feeders turned on alternatively on each section (figure 2a);
- waved: feeders turned on successively on each section, but with delay (figure 2b);
- grouped: feeders turned on alternatively at groups from several sections (figure 2c);
- platform: feeders work together at all sections (figure 2d).

In all modes feeder is in opened or half-opened position before appearance of rock/coal border. Then feeders turned off and draw mining stopped.
Figure 1. Draw mining method.

Figure 2. Sublevel caving modes scheme.

2. Development of models and research
Research of different modes of draw mining and definition rational mode is necessary. Solution of this task is complicated by high dynamics, instability and stochasticity of draw mining process because of non-constant volume and speed of unloading, longwall conveyor movement, feeders work, opened and closed feeder windows, different speed of unloading and each feeder, difference between opening and quantity contemporaneously opened feeder windows. All this leads to necessity of developing of
mathematical and program software for solving of task. Dynamism and plurality of random aspects of technology make difficult using of analytics models. For research and choice of draw mining mode we offer to apply simulating approach [8-16] without analytical description of processes. The approach has been successfully applied at researches dynamical changed systems including for mining works.

GPSS World is a tool for simulating modelling of robotized mechanical system. The tool is based on queue theory and allows to model processes which randomly changed at time and space. GPSS language and its versions are the most effective and prevalent programmed simulating discrete tools for computers, which successfully applied for mining work modelling [17-18].

Transacts and blocks are primary objects at GPSS-models. Transacts in model are discreet volumes of coal. Their movement from block to block is an imitation of sublevel caving and coal movement on conveyor. Feeders blocks and conveyor part blocks give logics of model system functioning and they define ways of transacts movements.

Programmatically implemented at GPSS-World model is on figure 3.

![Figure 3. Block diagram and GPSS-World model.](image)

To provide flexibility and efficiency of experiments with changing of input parameters there is a section for data entering (figure 4):

![Figure 4. Section for data entering.](image)

Synthesis of data entering sections, final of a simulation and models of all operations allows to develop simulating model of all robotized system.
For visualization of dynamics of draw mining through support sections and coal transportation by conveyor and also for evaluating of modelling results at Proof Animation we made animation which works under control of higher described simulation model (figure 5).

Figure 5. Sublevel caving animation fragment.

Static and dynamic elements are shown at animation: sublevel caving coal, sections of support, conveyor. Moreover, there is a table with following data for each area: coal flow, general mass of coal in conveyor (with previous areas). The volume of flow current mass flow is shown on animation corresponding to entered data of simulation model. At the first stage of animation coal from draw mining goes on conveyor through feeder of section (sections) of support. At this time column “current coal volume on conveyor part” there is a number which corresponds to general mass of coal on described area (with all previous). An information about general mass of coal from system is shown in message below. If system parameters and/or draw mining mode will be changed, shown animations will be corrected by simulation model.

Models allow to research draw mining in all modes, different sublevel caving speed from each feeder, different opening and quantity of parallel opened windows of feeders. Researches of higher described modes have been carried out with using of developed models. There are volumes of coal dependencies on conveyor part at figure 5. Model input data: section width – 2 m, window feeder width – 1 m, mass coal flow when unloading – 47 kg/s, coal mass from in section – 2 193 kg [19], shawl conveyor speed – 0.65 m/s, parts from 7 sections are in model, their length – 2 m. In individual mode feeders turned on alternatively on each section after the event when rock/coal border appears at previous feeder. In waved mode feeders turned on successively on each section with 20 seconds delay. In group mode feeders turned on alternatively in groups of 3 and 4 sections. In platform mode feeders work together at all sections with equal speed. Real conditions of underground work will provide unstable and stochasticity of draw mining process because of non-constant volume and speed coal.
unloading. Use of developed simulating models allows to evaluate considered modes with taking into account unevenness of speed and unloading volume on each section. 15% is a deviation in our researches.

Simulating results show (figure 6) that, in individual mode unloading of coal took 5 min 17 sec and there were 140 kg with periodical clusters. In waved mode unloading time was 2 min 40 sec and clusters were 423 kg with reducing to 280 kg. Group and platform mode provided faster unloading speed – 1 min 35 sec and 1 min correspondingly. However, there were not equability of unloading and coal clusters achieve 1 ton at 2 m.

Experiments show that waved mode provides more stable and full conveyor filling comparing with another modes. This conclusion confirmed by physical experiments on laboratory setup for researches the same unloading modes [20-21]. Thus, waved mode application is the most perspective for developing of technology of effective coal mining by robotized system with controlled draw mining method.

![Figure 6. Volume of coal on conveyor part at different modes with attention to stochastic unloading.](image)

3. Conclusion
Developed method allows to create at projecting stage models of robotized system for mining and geological conditions of application and equipment parameters. Models application provides an opportunity for definition of modes of automated control of unloading and section-type supports, unloading volume on each section, sequence and optimal quantity of working feeders. It will provide equable, constant and maximal equipment use.

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