Review of Mining Equipment with Controlled Robotized Subvel Caving with Specialized Software

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Abstract. Near 19 million ton of coal are mined with subvel caving. This is about 15% of all mined coal. Significant part of high qualitative coal is concentrated in thick seams (more than 4,8 m.). Subvel caving for thick seams is the main factor of mining efficiency. Specialized software has been developed for research and projecting of thick seams coal mining. It allows to automate the process of optimal mode choice with robotized subvel caving for different mining-and-geological conditions. We showed operating principle of the software and screen forms of data entering and output of modes simulating results for mining equipment with robotized subvel caving.

1 Introduction

Significant part of high qualitative coal is concentrated in thick seams (more than 4,8 m.). About 80% of coal from such seams are mined with underground method, including long pillar system. Part of coal remains in thickness layer and behind mining system when traditional technologies are applied. This volume will never be mined. According to different experts, producing a ton of coal, about three tons of proven reserves are considered as not available for ordinary technologies. That's why subvel caving is the main factor, which makes an influence on mining efficiency and rational environmental management [1-6].

Institute of coal of FRC CCC offers new technology of coal mining by mining equipment with robotized controlled subvel caving and thickness coal on conveyor. This approach allows to exclude disadvantages of similar systems with unloading on conveyor. The base of offered technology is using of feeders, which installed in special input windows of support [7,8]. Feeders construction helps to regulate coal mining production from each section on scraper conveyor by opening and closing of damper (fig 1).

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Fig. 1. Draw mining method.

Mining complex includes more than 100 sections of support with unloading, what demands co-work of feeders for provision of maximum load of conveyour. Optimal subvel caving mode is one of tasks, which delays application of this efficient technology.

There are results of experiments of research of subvel caving modes. Four modes are established in which the feeders are turned on alternately (individual); sequentially, but with a certain delay in time (wave); alternately in groups (group); simultaneously in all sections (areal) [9]. Research of these modes of coal unloading and determination of the rational mode has been carried out with use of math modeling. The paper [10] shows a conceptual model of a robotic complex with a controlled unloading, developed on the base of the math model of the queue theory in the form of a net of single and multiple SMO without negative limited enter of requests. The presents of a large number of controlled elements in the model, high dynamism, instability and stochasticity of the release process due to the unstable volume of coal unloading through windows, unloading speed and movement by conveyor didn't allow to apply analytical methods for model realization. That's why simulation approach has been applicated with use of GPSS World for complex systems modeling, including mining [11-13]. Developed model showed her efficiency and has been applied for determination of rational properties and modes of coal unloading for real mine conditions "Olzherasskaya-Novaya" Olzherassk field of Kuzbass.

2 Results and discussion

Developed model helps to solve tasks of determination rational modes of coal unloading, however special knowledge are needed for the system use – knowledge of programming, simulating, research planning.

Actual task is developing of specialized software which allows a mining engineer to automate the process of choosing the optimal operating mode of mining with a robotic controlled coal unloading of thickness seams.

Demands to software:

- An opportunity of technology simulating with entered mining-and-geological conditions and mining equipment parameters;

- An opportunity of choice of different unloading modes and sequence of sections start;
- 3D visualization of technological elements and dynamics of a process with an opportunity of view change and animation speed;
- Dynamic display of simulation results on the screen in graphical and numerical form. Report formation.

For software creation we used web-technologies which have been used to solve a wide range of problems, due to the presence of implemented and standard development tools, that allows us to implement functionality in all Web-browser. which is compatible to large “desktop” apps.

For a creation of a client side of interface to software part of a service the following information technologies have been used:

- for web-apps development: TypeScript – Microsoft programming language;
- for user interface: Vue.js – framework with opened base code;
- for 2D- and 3D-graph: Babylon.js (WebGL) – cross-browser light framework, which works without another apps and plugins.

Software and hardware part of the system based on multi-threaded programming language Golang [14], given by Google and used for aeration of modern and efficient systematic programs. It has simple and efficient integrated non-parallel tools, simple syntax based on C programming language.

WebSocket is used by server for connection in real time mode between browser and web-server.

Interaction between user and system has shown at figure 2 (“client-server”). The system generates model states according to entered parameters and deliver them to user. The system is afinal automatics, which used for representation of the data stream.

Fig. 2. Sequence diagram.

The interaction of server class in simulating of individual and group modes of subvel caving. At the moment when program starts, a server is automatically activated, which wait data on port 127.0.0.1:8081. Then, on the website for pre-setting the model, the requires operating mode is selected and all technology parameters requested by the system are entered. After that , connection to WebSocket server takes place and simulating results delivered to Web-client for displaying.

Fig. 3. Sequence diagram.

Figure 4 shows an example of parameters enter of group unloading mode. Each sections group is shifted by different colors. The speed of unloading speed is shown. Moreover, there is an opportunity of application the same settings for all groups. Also, there is an opportunity of using of similar pattern.

Fig. 4. Group mode parameters input and fragment of a 3D-model .

After model start, user will see the result as interactive animation (fig. 5.). There will be an opportunity of change scale and change of view angle. Current volume of coal on conveyor is shown as a dynamic graph.

Fig. 5. Simulating results.

3 Conclusions

Thus, the specialized software described in paper will help to automate the process of choice of an optimal mode of mining shearer with robotized controlled subvel caving for different mining-and-geological conditions.

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