THE MAIN TRENDS IN UNDERGROUND MINING TECHNOLOGIES TO OVERCOME THE RISKS AT RUSSIAN COAL MINES

Summary. The analysis of underground coal mining technologies and rate of accidents at Russian coal mines was executed. The main trends in technologies and other necessary measures to overcome the risks at Russian coal mines are presented.

GŁÓWNE TRENDY W TECHNOLOGIACH GÓRNICTWA PODZIEMNEGO W KONTEKŚCIE OPANOWANIA ZAGROŻEŃ WYSTĘPUJĄCYCH W ROSYJSKICH KOPALNIACH WĘGŁA KAMIENNego

Streszczenie. W artykule przedstawiono analizę technologii górniczych, stosowanych w rosyjskich kopalniach węgla kamiennego, wraz z ich wskaźnikami wypadkowości. Zaprezentowano główne trendy dotyczące stosowanych technologii oraz inne niezbędne środki podejmowane w celu opanowania zagrożeń występujących w rosyjskich kopalniach węgla kamiennego.

The coal industry of Russia in the 21-st century is characterized by the stable production increasing, especially at open pit mines (fig. 1). According to the government-accepted program of coal industry development in 2030 the total coal production will reach 420 million tons that almost on 100 million tons exceeds the level reached in 2011.

Growth of coal production is expected by putting into operation the new coal mines and open pits, as well as increasing productivity at the already operating coal getting enterprises. Now in the Russian coal industry are operating 109 underground mines and 218 open pit mines, 164,8 thousand people are employed. The number of coal mines where operated only
one longwall with annual productivity 2.0 – 4.4 million tons are continuously increasing. During 2000-2011 the longwall average daily output increased almost triple at almost double reduction of quantity of operating longwalls (fig. 2).

![Coal production in Russia, million tons](image1)

**Coal production in Russia, million tons**

Fig. 1. Coal production in Russia during 2000-2011
Rys. 1. Wydobycie węgla kamiennego w Rosji w latach 2000-2011

![Longwall productivity and number of longwalls](image2)

**Longwall productivity and number of longwalls**

Fig. 2. Longwall productivity and number of longwalls during 2000-2011
Rys. 2. Wydobycie ze ściany oraz liczba ścian w latach 2000-2011

At the same time, growth of coal production is accompanied with unacceptable level of accidents and traumatism, especially at underground coal mines (fig. 3). In some years (2004, 2007, 2010) the rate of fatal accidents for coal mines varied from 1,18 to 1,9 per 1 million tons of production, when average value of this indicator for open pits was 0,07. The worse year when at the coal getting enterprises 232 people were mortally injured (216 of them at coal mines) was 2007. The most part of accidents were the group accidents caused by explosions of methane and a coal dust. Accident rates stimulated by both difficult geological
conditions at the Russian coal mines and applying the methods of methane emission control and ground control that inappropriate to the longwall productivity, provided by the modern equipment. The preliminary degasification of coal mine fields isn't applied at the Russian mines and that essentially complicates a problem of effective methane emission control and transfers the need of its decision directly at longwall panels. Average depth of mining during 2000-2011 increased from 380 to 425 m and at Vorkutskoe coal deposit reached 1100 m. It becomes more complicated the effective gas emission and ground control at mines.

The analysis of rate of fatal accidents in Russian coal industry (fig. 3) shows that the tendency to the fatal accidents rate reduction is unstable and level of a traumatism remains unacceptable. The decreasing of rate of fatal accidents per 1 million tons of coal production down to 0,05 by 2030 is declared as one of the purposes of the long-term program of Russian coal industry development. According to this program to increase the mine safety level is planned to realize some measures. Among them:

- Increasing of the federal regulation efficiency in the field of mine safety and health as well as environment protection;

- Implementing to the coal industry the risks management system based on the best Russian and foreign experience and modern concepts.

It is possible to allocate 4 groups of the factors that have strong influence on coal mines safety: natural factors, technological factors, behavioral and connected with behavior of employees (organizational factors).
The fast growth of longwall productivity and longwall advance rate has resulted intensive changing of stress and strain distribution in the rock mass. It accelerates the importance of the quality of the longwall panels mining projects. The separate solution for longwall panels such questions as ventilation, fire protection, degasification, dust suppression, rock burst and sudden gas outburst prevention doesn't solve an accident prevention problem. The complex consideration of the matters in connection with accepted planning decisions for specific conditions is necessary.

At the same time, the federal regulation base concerning design of longwall mining system wasn't updated for a long time. It concerns such questions as methane emission control, ground control, panel planning and development. The document where all these questions are considered as a complex in connection with specific geological conditions – an album of technological schemes of coal seam mining at coal mines – was published in the USSR in 1991 by mining institute of A.A. Skochinsky. The urgent need in essential updating of regulatory base by taking into account present realities and the latest achievements in the theory and practice of underground coal mining now is obvious. First of all, the technological schemes of coal seam mining have to be modernized. Because of the absence of such document for Russian coal industry the coal companies and project institutes have difficulties with development and the subsequent state expertise of coal mining projects where are put modern longwall panel design and development decisions providing high longwall productivity and sufficient level of safety. Such situation stimulate some leading coal-mining companies of Russia together with the science and projects organizations to began the technological schemes development for conditions of their mines. The requirements to schemes remain invariable – ensuring high efficiency and safety of the underground coal seams mining.

The analysis of experience of high-efficiency longwall mining at coal mines all over the world allowed to determine the main trends in longwall mining technology and to formulate the directions of improvement of technological schemes of longwall mining at Russian coal mines:

- Modern high-efficiency longwalls equipped by machines with a resource of 5 million tons and more; equipment made individually for specific geological conditions of a certain coal seam at the certain part of a minefield;
- The width of longwall panels has obvious trends to growth – at USA coal mines it reached 5% per year and the maximum value – 540 m, the length of some longwalls at Russian coal mines exceeds 300 m;
- The length of longwall panels can exceed 4000 m and also tends to growth. It is usually limited by geological conditions of minefield while the modern longwall equipment are capable to mine panels with considerably bigger length;
- The longwall panels development scheme with two entries at each side of coal face now is most popular at Russian coal mines. The world most productive longwall (USA) extracted the panel that was developed with three entries and at some USA coal mines operates the longwall panels with four entries at each side of coal face;
- Criteria for a choice of a scheme of longwall panel development is ensuring complete use of technical possibilities of the applied equipment and the complex solution of such questions as methane emission control, fire protection, prevention of rock bursts and sudden gas outbursts, minimization of losses of coal in pillars;
- As the pillars between entries are one of key elements in multientries panel development schemes, additional researches of pillars stability in various modes of loading and rates of longwall advance are required;
- Timely reproduction of the longwall panels with multientries schemes of panel development requires essential increasing of entries development rate.
- Other important direction of mine safety level increasing is introduction of the modern automated systems of monitoring and control of various mine subsystems. Among them it is possible to allocate:
  - Systems of supervision, the people notification about failures, continuous control of location of the personnel in mine;
  - Systems of the automated aero gas control and gas protection;
  - Systems of monitoring the stress-strain statement of the rock mass;
  - Automatic systems of methane and coal dust explosions localization;
  - Systems of underground fires detection at early stages of development;
  - United mines control system (united dispatching service) for the companies, providing united dispatching control of life support and safety systems, as well as systems of technological processes control.

Miners are the key element in the mine safety. The risks decreasing at the coal mines is impossible without personnel training, increasing of labor discipline, and also the measures of the personnel motivation for work without violations of safety rules. Also it is necessary to decrease the number of underground workers, transit to full automated mining technologies and improve the devices and systems of individual and collective protection of workers.
The financing of mine safety improving works is provided within various federal programs. Another way to obtain financing is stimulation the coal mining companies to invest in safety. To increase efficiency of interaction between the coal companies, project and research organizations, government and mine safety administration the technological platform «Firm mineral resources» is created. The National University of Mineral Resources (University of Mines) is a member of this platform. The continuous joint efforts of all interested parties is the only way to reach the main goal – decreasing of risks level at the coal enterprises to acceptable level and ensuring production efficiency.

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Omówienie

Wydobycie węgla kamiennego w latach 2000-2011 przedstawiono na rys. 1. Zakłada się, że do 2030 roku roczne wydobycie osiągnie wielkość 420 milionów ton. Wzrost produkcji górniczej ma nastąpić dzięki uruchomieniu nowych zakładów górniczych oraz wzrostowi produktywności w istniejących kopalniach, czego przejawem jest między innymi zwiększenie średniej wielkości wydobycia ze ściany – rys. 2. Jednocześnie obserwuje się niekorzystną tendencję do rosnącej wypadkowości towarzyszącej wzrostowi wydobycia – rys. 3. W kopalniach podziemnych węgla kamiennego wskaźnik wypadków śmiertelnych wynosi od 1,18 do 1,9 na milion ton wydobycia. Największą część wypadków śmiertelnych stanowią wypadki grupowe spowodowane przez wybuchy metanu i pyłu węglowego. Przyjęte przez rosyjski przemysł węglowy plan poprawy bezpieczeństwa w kopalniach węgla kamiennego zakłada obniżenie śmiertelności w górnictwie węglowym do poziomu 0,05 na milion ton wydobycia w 2030 roku. W artykule przedstawiono szczegóły strategii poprawy bezpieczeństwa w rosyjskim górnictwie węglowym, obejmujące między innymi zmiany w obowiązujących przepisach oraz wprowadzenie systemów zarządzania ryzykiem w zakładach górniczych. Jednocześnie przewiduje się wprowadzenie zmian w technologii wydobycia, umożliwiających zarówno wzrost efektywności produkcji górniczej, jak i poprawę bezpieczeństwa i kontroli zagrożeń naturalnych. W artykule wymieniono kilkanaście założeń strategii zmian w projektowaniu, wyposażeniu i prowadzeniu ścian eksploatacyjnych w kopalniach. Zwrócono także uwagę na konieczność wpływu na zmiany zachowań górników w kierunku zwiększenia dyscypliny pracy i przestrzegania przepisów BHP oraz na potrzebę poszukiwania źródeł finansowania inwestycji w dziedzinie bezpieczeństwa pracy w kopalniach.