

A Summary of the Research on Maintaining the Safety of the Coal Seam with a Large Dip Angle

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Abstract

According to the distribution of coal resources, the coal seam with a large dip angle occupies a high proportion, and the mining of this kind of coal seam is paid more and more attention. But it is very difficult to mine because of its big dip angle, big thickness change, and brittle and easy caving. How to overcome these difficulties effectively and realize the safety mining of large inclined coal seam is an important research topic in the field of coal seam mining. In this paper, firstly, the characteristics of high inclined coal seam are summarized and based on the characteristics of the coal seam, the mining methods of this kind of coal seam, and the equipment used in the development of high inclined coal seam in China are summarized. Secondly, according to the difficulties of the mining coal seam, the mining theory and technology put forward by predecessors when solving these difficulties are summarized. Finally, combing the previous work related to the maintenance of coal seam safety, and put forward the prospects for future safety monitoring.

Keywords

Large Dip Seam; Coal Mine Safety; Mining Technology; Mining Method.

1. Introduction

Coal, is the main power to promote the development of the global economy, with the increasing global demand for energy, the mining volume is also increasing year by year[1]. When the coal resources stored in the low level or gently inclined coal seam with simple geological conditions and shallowly buried depth decrease with the increase of mining intensity, people begin to look for the deeper or inclined coal seam. Due to the influence of geological structure, more than half of the coal seams with large dip angles are high-quality coking coal and anthracite, so the coal seams with large dip angles gradually become the main mining coal mines[2].

The large dip angle coal seam is the coal seam with a dip angle from 35 ° to 55 °, which is recognized by mining scholars both at home and abroad as the coal seam with great difficulty in fully mechanized mining[3]. One-seventh of China's coal reserves belong to the coal seam with a large dip angle, mainly distributed in the northeast, Inner Mongolia, Sichuan, Fujian, and Guangdong provinces. Nearly half of Sichuan's coal production comes from coal seams with large dip angles. However, because of the complex structure of this kind of coal mine, there are some safety problems, which are not conducive to the safe mining of large inclined coal seams. Therefore, it is of great significance for the development of the coal mining safety industry to research the safety mining of large inclined coal seams.

2. The Mining Characteristics of the Coal Seam with a Large Dip Angle

The initial state of coal seam formation is horizontal, after a certain number of geological transformations into a large dip angle coal seam. There are many faults and folds in this kind of coal

seam, and it has the characteristics of large dip angle, high thickness, and brittle and easy falling[4], So the mining difficulty is more difficult to mine than near-level mines. First of all, the roof and upper coal seam mining process in the face filling is not uniform, resulting in mine pressure difference will seriously threaten the safety of the working face. Secondly, the movement of coal and rock strata in the process of mining in a large dip-angle face will lead to the unbalance of the stable supporting equipment and even the irregular displacement of the whole transportation system of the face. Finally, the increase of dip angle and the lateral slip of coal and rock will bring about the change of dip angle of mining face equipment, thus increasing the possibility of lateral dip of working face. Therefore, in the mining engineering of a large dip angle working face, it is necessary to grasp the distribution law of mining pressure and the support mode of equipment, to ensure the safety and production efficiency of the working face[5].

3. Research on Mining Methods and Equipment

3.1 Mining Methods

Manual coal mining is the most primitive method of coal mining, this method not only has low efficiency, and a large workload, but also the safety of staff life threats. Then began semi-manual and fully mechanized, automated mining development. The main mining methods of large inclined coal seam are divided into underground mining and steep seam mining[6].

3.1.1 Underground Coal Mining

From the coal mining utilization rate as well as the popularity, the highest ranking is underground coal mining. This coal mining method mainly includes dry mining and water mining, which need to be selected according to different scenarios[7]. Generally speaking, if there is water in the mine, use water mining, otherwise dry mining. Comparatively speaking, the utilization rate of dry mining is higher, mainly because it has higher mining efficiency and convenient construction, etc. . There are two main mining methods in dry mining: pillar method and wall method. Pillar mining has been banned because of its high risk and low recovery rate, although the initial cost is lower and the supporting equipment is less[8]. The wall mining method can be classified according to the thickness of the coal seam and the direction of advancement. The characteristics of wall mining are that the working face is long and the two ends are connected, and the efficiency of the whole mining method is higher than that of pillar mining.

3.1.2 Coal Mining in the Steep Seam

Due to the different conditions between the large inclined coal seam and near-horizontal coal seam, it is necessary to select fully mechanized mining equipment and mining methods before mining. At the same time, it is necessary to define the mining area to ensure the safety of coal mine production. At the same time, it is necessary to further change the structure of the roadway, and enhance ventilation, to achieve rapid and smooth mining of coal.

3.2 Mining Equipment

In the 1970s and 1980s, fully mechanized coal mining equipment was introduced into China on a large scale, and the coal mining method gradually took the place of manual coal mining, blasting coal mining, and general semi-mechanized coal mining. Through digestion and absorption of foreign fully mechanized mining equipment, and a large number of field tests and research, gradually develop domestic fully mechanized mining technology and equipment research and development. The first hydraulic support standard was issued in 1984, which marked the beginning of fully mechanized mining technology and equipment research and development in China.

[10] from 1985 to 2000, the technology and equipment of fully mechanized coal mining entered the stage from digestion and absorption to independent research and development. During this period, we began to research and develop fully mechanized mining technology and equipment suitable for various thicknesses of coal seams and developed various special types of hydraulic supports for different inclined coal seam conditions, gradually forming a fully mechanized mining hydraulic

support design theory and method system. At the same time, the technical standards of hydraulic support and other fully mechanized mining equipment have been formulated, and the domestic manufacture of common hydraulic support, Shearer, and transportation equipment has been preliminarily realized.

To reverse the situation that China's high-end fully mechanized mining equipment market has been monopolized for a long time by foreign coal machinery enterprises, China has launched the research and development of domestic high-end hydraulic support, in 2003, the first set of hydraulic support with 5.5 high mining height electro-hydraulic control system was successfully developed. Subsequently, the coal research institute and Related Enterprises developed fully-mechanized mining equipment and improve the technical standard system of hydraulic support, completely changing the situation of China's high-end fully-mechanized mining equipment's long-term dependence on imports.

4. Research on Mining Theory and Technology

In the 1970s, some relevant scientists and researchers in the former Soviet Union began to discuss and analyze the safety in the production of large inclined and steeply inclined coal seams, the coal cutting machine, and hydraulic support which can adapt to these conditions have been developed successfully[11]. And the comprehensive mechanized production technology of large inclined seam is studied scientifically and comprehensively, which lays the foundation for the production technology research of large inclined coal seam[12-13].

After collecting a large amount of data, professor Jia Defeng has made a rigorous analysis of the problems that occurred in the course of pseudo-oblique mining in the working face of a large inclined coal seam[14], Wu Yongping [15] has given the concrete method of adjusting pseudo-elevation in the working face when using strike longwall mining method in the coal seam with large dip angle. At the same time, the factors causing the surrounding rock disaster are studied, the "R-S-F" system is put forward, and the general dynamic equation of the "R-S-F" system is derived.

[16] taking the geological and mining technical conditions of the Lvshuidong coal mine as the engineering background, the mutual working mechanism of long-wall pseudo-pitching "support-wall rock" is studied. It is concluded that the pseudo-depression of the long wall in the coal seam with a large dip angle has the characteristics of zoning and time sequence, and the effect and effect of support in different areas are different.

[17] based on the study of the movement law of overlying strata in longwall mining of large dip angle coal seam, the mining method of local filling is put forward based on the disequilibrium of goaf caused by the broken roof and caving roof after mining, to achieve the goal of stable mining. [18] based on [17], the filling materials were studied. The results show that the local backfilling mining of gangue can effectively control the movement of strata.

[19] taking the second mining area of Jiangcang niangmute coal mine as the specific research object, the ground pressure law and the breaking law of the overlying frozen soil layer in the mining of the coal seam with a large dip angle under the permafrost layer are studied, it is of great significance for the safe and efficient mining of coal seam under permafrost layer.

Reference [20] puts forward the combined support scheme of "anchor net and cable beam" for the special-shaped stoping roadway. To provide a reference for the stability of similar roadways, the support cost and labor intensity in the mining process are reduced.

[21] taking Changshanzi coal mine as the research object, analyzing and studying according to the actual coal mine conditions, this paper gives the cause of falling frame in fully mechanized top coal caving face with big dip angle in three soft medium layers and puts forward a dynamic method of "supporting-walking-fixing-supporting" used in three soft working faces to solve the problem of the falling frame.

[22] through the study of the geology of the large dip angle coal seam and the regularity of ground pressure in the Lujiatuo mine, the anti-slip and anti-fall measures of fully mechanized mining

equipment are improved. In the production process, technical innovation is carried out from the intrinsic safety aspect of the facilities, and the measures of preventing the waste rock from falling and injuring people are perfected in the working face with large inclination.

[23] to study the relationship between the roof structure and support load of fully mechanized top coal caving face in a large inclined seam group, relationship between the roof structure and support loads of fully mechanized top coal caving face large inclined seam group were studied, the calculation formula of support load between upper and lower coal seams is obtained.

5. Research on Safety Protection Measures

According to statistics, although the equipment and technology of coal mining are improving, the casualties caused by coal mine accidents still exist every year[24]. Feng Yufeng et al. [25] expound on the course and experience of coal mine safety development in the founding ceremony of the People's Republic of China, whether the coal mine safety accident will happen or not depends mainly on the perfection of the system, the intellectualization of equipment and technology, and the safety consciousness of personnel, etc. at the same time, constantly strengthen the safety awareness of staff and improve the monitoring system.

To ensure the safety of underground personnel and equipment, reference [26], by analyzing and comparing with the scientific and technological support system of safe production at home and abroad, established a system in line with the situation of our country and proposed that the pilot application be carried out in the whole country. Reference [27] proposes to use electronic monitoring instead of manual monitoring and to use real-time monitoring of toxic gases and Iris technology based on radio frequency identification (RFID) for personnel clock-in identification. Reference [28] suggests that camera systems, strobe lights, and other devices can be developed to improve visibility and thus solve the problem of poor light visibility. [29] for intelligent coal mine, it is proposed to establish underground location service and space perception field to realize the accurate location of personnel and equipment, and to provide edge computing and cloud computing service to realize equipment data interconnection.

6. Conclusion

Coal will still be the main energy source in China for some time to come. With the gradual exploitation of near-horizontal coal seam resources and the development of high-quality coal seams with large dip angles, the advantages of the latter are gradually highlighted. The formation conditions of large dip angles coal seam are complex, so the mining method of near-horizontal coal seam can not be referred to singly. Before mining, we should study the dip angle of the coal mine and the thickness of the coal seam, select the appropriate fully mechanized mining equipment, and make the corresponding equipment or technical adjustment for the safe mining of coal according to the previous research. At the same time, compared with the horizontal coal seam, the dip angle of the big dip angle coal seam changes greatly, and the phenomenon of support toppling and biting occurs frequently. The research of intelligent monitoring facilities and equipment is the inevitable trend of technology development, and also the realistic demand for coal mining. In the future, it is necessary to make further research on the monitoring equipment for the safety of steep seams.

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