Mine Pressure Observation and Support Adaptability Analysis of Fully Mechanized Caving Face in Soft Rock Mine

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Abstract: According to the data monitored by the top pressure gauge of the I0128\textsuperscript{2}04 fully mechanized caving face in Yannan Mine, the statistical analysis method is used to analyze the adaptability of the hydraulic support. The results show that the ZFS6400-15.7/31 bracket support strength is suitable for soft rock fully mechanized caving. It provides technical guarantee and reference basis for the selection of similar working face brackets.

1. Introduction

With the development of equipment technology and the optimal utilization of coal resources, fully mechanized caving mining has gradually become the main mining method for thick and extra-thick coal seams in China. Its technological advancement is mainly reflected in high output, high efficiency and low energy consumption. However, in the actual application process of fully mechanized caving mining technology, according to the actual conditions of different mines, there are also some problems such as technical parameter determination and application law exploration, such as: bracket-surrounding rock relationship, section stability control, top Dynamic stability of coal, large supporting equipment, etc. [1].

The adaptability of the fully mechanized caving face support (support resistance characteristics, initial support force, utilization rate, etc.) is an important index to evaluate whether the support meets the production requirements and safety factor of the working face, and can also analyze the deformation and motion characteristics of the surrounding rock from the side. In this paper, the KJ216 roof pressure monitoring system is used to observe the working face, and the statistical analysis method is used to analyze the observation data. The adaptability and working status of the bracket are comprehensively evaluated, which provides the basis for the selection of the working face bracket. Under the conditions of fully mechanized caving face mining, improving coal recovery rate are of guiding significance. In particular, it provides a scientific basis for the adjustment of the I0128204 fully mechanized caving face and the management of the roof.

2. Project Overview

Yannan Coal Mine I0128\textsuperscript{2}04 fully mechanized caving face elevation: +656--+664 m, downhole elevation: +315--+533 m, east adjacent to the minefield boundary 17 exploration line, west to +350 stone gate, south adjacent section 28-2 coal seam The mining body is adjacent to the third section of the 28-2 coal seam goaf in the north; the average recoverable length is 1614 m, the average inclined length is 180 m, the area is 290520 m\textsuperscript{2}; the average coal seam thickness is 5.9 m, the coal seam
average inclination is 8°, and the bulk density is 1.23 t/m³, recoverable reserves of 1,791,800 tons; adopting the long-wall retreat mining method, the coal-removing method is fully mechanized caving, the shearer cuts coal in both directions, the end is inclined, and the cycle progress is 1.2 m, using two shifts.

2.1 Mining Technical Conditions
(1) No. 282 coal seam is lignite. The coal seam and surrounding rock are coal-bearing rock sections of the central part of the Datunjiao Formation of the Lower Cretaceous, with a coal seam trend of 8°-263° and a tendency of 278°-353°. The dip angle of the coal seam varies greatly. The dip angle of the coal seam near the 19 exploration line is 2°, and the dip angle of the coal seam is 17° near the F5 fault of the 17 exploration line. The average dip angle of the coal seam in this working plane is 8°.

(2) The No. 282 coal seam is a thick coal seam. The overall average thickness is 5.9 m in the mining area. The height of the front and rear lanes is 2.80 m, the average thickness of the top coal is 3.00 m, and the average thickness of the bottom coal is generally 0.95 m. The coal seam is a stable coal seam in the mining face, the thickness of the coal seam does not change much, and the thickness of the coal seam is slightly thicker than that of the east; the thickness of the sandwich layer varies greatly, the thickness of the Δ3 varies by 0.70-0.10 m, and the thickness of the Δ3 in the west is 0.10 m, to the east, the thickness is 0.70 m. The thickness of Δ4 clip varies from 0.70 to 0.02 m, and the thickness of the Δ4 clip is 0.02 m in the west and 0.70 m in the east.

(3) The pseudo-top of No. 282 coal seam of this working face is 1.83 m thick fine-grained sandstone with poor cementation, loose and easy to fall, and the direct top is 4.60 m thick mudstone with poor consolidation and swelling with water. Soft; above the top is 4.25 m fine-grained sandstone, the consolidation is poor, easy to be loose. The bottom plate is gray-black sandy mudstone with a thickness of 7.00 m, poor consolidation, softer, and water swelling.

(4) Geological structure, I012804 fully mechanized caving face excavation saw 13 positive faults, including 10 in the mining face and 3 outside the working face. There is one fault with a large drop in the working plane. The F2012-01 fault has a drop of 3.50 m. It is expected that the fault will extend from east to west and reach about 140 m in the working plane. The coal seams near the faults are broken and the joints are developed. The pressure on the top is large and the maintenance is difficult.

(5) In the hydrogeological situation, the upper part of the working face is 27-1 coal seam section and the second section working face goaf, and no water is found during the mining. Therefore, it is determined that there is no water in the goaf, and the second section of the 28-2 coal seam is working. Surface mining does not constitute a water hazard. In addition, due to structural influences, coal seam joints and fissures are developed during the excavation process of this working face. At the transfer roadway, 2 o'clock east from 28 m to D6 point, return wind F19 point east from 91 m to 100 m, F21 point east 101 From m to 257.4 m, the opening and cutting of the 1’ point is from 24 m to 118.6 m in the south, with dripping and watering, and the water output is 2-5 m³/h. The roof of the coal seam is gray-white fine-grained sandstone, which is water-containing, loose and easy to fall. When the top coal is recovered from the working face, it is easy to turn on the sandstone water of the roof. Therefore, it is necessary to strengthen the water management of the working face. It is expected that the maximum water inflow of the working face is expected. At 10-20 m³/h.

2.2 Working Face Main Equipment
I012804 is a fully mechanized caving face. According to the existing equipment of mining company, it adopts: ZFS6400-15.7/31 type 114, ZFG6400-22/30H type 6 tail beam inserting plate low position type fully mechanized caving bracket, MG300/700-WD type One coal mining machine, two SGZ-764/630 (315kw×2) scraper conveyors, one SZZ-830/315 bridge type transfer machine and one PLM-1800 type crusher.
3. Mine Pressure Observation Program

3.1 Purpose of Observational Research
Through on-the-spot observation and research, we grasped the law of mine pressure manifestation of the 1012804 fully mechanized caving face in Yannan Mine, evaluated the adaptability of the soft rock working face bracket, and analyzed the coal caving effect of the working face according to the actual conditions of the working face. At the same time, through comprehensive analysis and research on the technical and economic benefits of the working face, comprehensively evaluate the technical status of the working face, and propose solutions to the actual problems, so as to realize the scientific and standardized management of the production of the working surface.

3.2 Working Surface Observation Content
There are three observation and measurement areas along the working surface, which are respectively set on the working surface, middle and lower parts, and brackets No. 100, No. 80, No. 60, No. 40 and No. 20, and one KBJ- is installed in each bracket in the observation area. The 60III-1 digital pressure gauge observes the load on the front and rear columns of the bracket. During the observation period of 50 days, during the observation period, the working face completed a total of 100 production cycles, a total of 100 m, and the specific observation points are arranged as shown in Figure 1.

Fig.1 Arrangement of observation points of 1012804 fully mechanized caving face
4. Analysis of Mine Pressure Law and Stent Adaptability

4.1 Working Surface Top Plate Pressure Curve Analysis

The parameter variation curves of the 1 line (20 bracket) and 2 line (40 bracket) in the lower part of the working face are shown in Fig. 2 and Fig. 3. It can be seen from the figure that the lower part of the working face 1 is the No. 20 bracket of the measuring line, and the whole curve of the pressure curve is balanced, there is no obvious undulation and signs of pressure; the lower part of the working surface 2 is the No. 40 bracket, and the observation pressure is 3 times, and the cycle comes. The pressure step is 17.6 m for the first time and 25.6 m for the second time. The pressure is obvious and lasts longer. The third time is 16.5 m, and the cycle step is between 16.5 and 25.6 m. The average cycle is 21.05 m.

![Figure 2 No. 20 bracket pressure curve](image)

![Figure 3 No. 40 bracket pressure curve](image)
The parameter variation curve of the 3 measuring line (60 bracket) in the middle of the working face is shown in Fig. 4. It can be seen from the figure that the No. 60 bracket of the working face is pressed three times, the cycle is the first time 5.15 m, the second time is 21.35 m, the third time is 22.65 m, and the cycle step is from 5.15 to 22.65 m. During the average cycle, the pressure step is 13.9 m. The curve undulation is not very large during the whole pressure, and the pressure is not obvious. The pressure step is longer after the two times, and the pressure is longer.

The parameter variation curves of the 4 measuring lines (80 brackets) and 5 measuring lines (100 brackets) on the working surface are shown in Fig. 5 and Fig. 6. It can be seen from the figure that the No. 80 support on the working surface section 4 observes the incoming pressure 5 times, the first step of the pressure step is 8.15 m, the second is 7.8 m, the third is 20.15 m, and the fourth is 6.5 m, the fifth step of 15.9 m cycle is between 6.5 and 20.15 m, and the average cycle pressure step is 13.25 m. The curve fluctuation is obvious during the pressure. The surface of the working surface is 100#, the observation is coming. Pressing 5 times, the cycle is 1.55 m for the first step, 8.95 m for the second time, 8.15 m for the third time, 9.45 m for the fourth time, and 22.15 m for the fifth time. The apparent step is small and the duration is constant. Short, the cycle step is between 5.55 and 22.15 m, and the average cycle is 13.85 m.
In general, during the observation period, the lower bracket period of the working face is pressed 3 times, the pressure step is 16.5-25.6 m, and the average period is 21.05 m. The curve is not obvious during the pressure period; the middle bracket period is pressed 3 times. The pressure step is between 5.15 and 22.65 m, and the average period is 13.9 m. The upper part is subjected to 5 cycles of pressing. The pressure step is between 5.55 and 22.15 m, and the average period is 13.85 m. The pressure of each part of the working face is observed and analyzed. There is a significant difference in the time of appearance, and the difference in the pressure step is also large, and the pressure on the working surface is more obvious.

4.2 Stent Adaptability Analysis

4.2.1 Analysis of Initial Support Data

The initial support force and utilization ratio of the working surface observation bracket are shown in Figure 7, which can be seen from the figure:

1. The average initial support force of the working face bracket is 7.33~33.25 Mpa. Among them: 20# bracket is 8.24~24.99 Mpa, 40# bracket is 9.76~21.15 Mpa, 60# bracket is 7.73~20.12 Mpa, 80# bracket is 11.59~33.25 Mpa, and 100# bracket is 7.33~22.32 Mpa. The initial support force of the working face bracket is low, which is lower than the prescribed initial support force of 28 Mpa.

2. The average utilization rate of the initial support of the working face bracket is 27.6%~118.8%. Among them: 20# bracket is 29.4%~89.3%, 40# bracket is 34.9%~75.5%, 60# bracket is 27.6%~71.9%, 80# bracket is 41.4%~118.8%, 100# bracket is 6.2%~79.7%. The utilization rate of the initial support force of the working face bracket is low, which is lower than the specified requirements.

3. The initial support force of the working face bracket is lower than the lower limit of 9.5%~73.8%. Among them: No. 20 bracket is 10.7%~70.6%, 40# bracket is 24.5%~65.1%, No.60 bracket is 28.1%~72.4%, No.80 bracket is 9.5%~58.6%, and No.100 bracket is 20.3%~73.8%.

4. The initial support force of the working face is distributed along the whole working surface as the lower part is larger than the upper part, and the upper part is larger than the middle part by 16.2%; the lower part is larger than the middle part, and the middle part is larger than the upper part; the upper part is larger than the lower part, and the lower part is larger than the middle part. 43.2%; the upper part is larger than the middle part, the middle part is 21.6% in the upper part; the middle part is larger than the upper part, the upper part is larger than the lower part; the middle part is larger than the lower part, and the lower part is larger than the upper part; the ratio is 5%; The initial utilization of the surface is distributed as the upper part is larger than the lower part and the lower part is larger than the middle part.
According to the above data, the initial support force of the working face bracket is low, and the reasons for this situation are as follows: some of the working surface brackets are leaking and simmering in the production process, and the maintenance is not timely; the coal seam roof is broken and sucked by the working face. The top beam of the bracket is not tightly connected; the height of the working face is too high, and the bracket is not tight; the operation of the racker is not in place, resulting in the initial support of the bracket not meeting the specified requirements.

4.2.2 Work Resistance Data Analysis
The working resistance and utilization ratio of the working surface observation bracket are shown in Figure 8. It can be seen from the figure:

(1) The working resistance of the working face bracket during the observation period is 4.94~36 Mpa. Among them: 20# bracket is 7.88~21.53 Mpa, No.40 bracket is 13.25~32.47 Mpa, No.60 bracket is 9.33~24.12 Mpa, No.80 bracket is 16.11~36 Mpa, and No.100 bracket is 4.94~29.17 Mpa.

(2) Working resistance of working face is 15.1%~110.4%. Among them: No. 20 bracket is 24.2%~66%, No.40 bracket is 40.6%~93.6%, No.60 bracket is 28.7%~74%, No.80 bracket is 49.4%~110.4%, and No.100 bracket is 15.1%~89.5 %.

(3) According to the working resistance utilization of the bracket, it can be concluded that the ZFS6400-15.7/31 bracket support strength is suitable for the mining conditions of the working face and meets the support requirements; the working resistance of the working surface bracket is 110.4%, mainly due to the working resistance during the pressure. When the rated working resistance of the bracket is exceeded, the safety valve is not opened in time due to artificial setting or damage and is caused by liquid return.

(4) After monitoring and analysis, the statistical qualification rate of the whole surface working resistance during the observation period is 20.4%~65.86%, of which the work resistance rate is 20%~30% for 4 days, and the work resistance rate is 30%~40%. In the day, the work resistance rate is 40%~70% for a total of 13 days. Therefore, the ZFS6400-15.7/31 hydraulic support used in this working face can meet the requirements of this working face.
5. Working Face Support Management Measures

1. During the observation, some working face brackets are found to be leaking and simmering, and the safety valve is not sensitive. The maintenance and management of the bracket should be strengthened, and hidden dangers should be eliminated in time.

2. The initial supporting force of the bracket is partially lower. This is because the top coal strips fall and form a partial empty top above the bracket. This is unfavorable for the performance and safety assurance and management of the bracket, and should be avoided.

3. Strengthen the coal cutting and shifting management of the unit, and strictly follow the operating procedures and operating procedures to achieve sufficient initial support, and the top beam is connected to the top plate.

4. Strengthen the inspection and repair work of the bracket to ensure the stable work of the bracket and effectively support the roof.

5. The bracket must be in place during the shifting operation. Ensure that the end face of the top beam is not more than 340 mm from the coal wall of the working face.

6. In the working face mining project, it is necessary to strengthen the management of the mining level to prevent the occurrence of the bracket trap, the top beam not to be connected, and the top leakage phenomenon.

7. It is necessary to strengthen the management of the work face tail 118#-120# bracket and the head 1#-3# bracket. Because the working face has a large dip angle, it may fall and dump, and it must be adjusted in time. The coal shovel in the roof of the tank is kept to prevent the slippage and dumping of the bracket.

8. During the pressure of the top plate, it is necessary to strengthen the support quality of the working face, speed up the advancement of the working face, and reduce the exposure time of the coal wall and the roof of the working face.

6. Conclusion

1. During the observation period, there is a significant difference in the pressure display time of each part of the working face. The difference of the pressure step is also large. The pressure on the working
surface is more obvious. The pressure step at the lower part of the working surface is 16.5-25.6 m. The cycle pressure is 21.05 m; the middle step is between 5.15 and 22.65 m, and the average period is 13.9 m; the upper step is 5.55 to 22.15 m, and the average period is 13.85 m;

(2) From the analysis of the initial support force, the initial support force of the working face bracket is low; from the utilization ratio of the working resistance of the bracket, the support strength of the ZFS6400-15.7/31 bracket is suitable for the mining conditions of the soft rock fully mechanized caving face.

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References
[1] Qian Minggao. Scientific development of coal [J] Journal of China Coal Society, 2010, 35(4): 529-534.
[2] Li Jinhua, Wang Yuchun. Adaptability analysis of fully mechanized caving face support [J] Coal Science and Technology, 2012, 03: 101-103.
[3] Xu Qingyun, Huang Qingguo, Li Yongming. The law of mine pressure behavior during the mining period of fully mechanized caving face in Buliangou coal mine [J] Coal Science and Technology, 2013, 41(06): 33-37.
[4] Bie Xiaofei, Yan Xinxian, Zhang Shuai. Research on the mining pressure law of fully mechanized caving face in the extra-thick coal seam of Qianqiu Coal Mine [J] Coal Science and Technology, 2013, 41(Supplement): 80-82.
[5] ZHANG Bo, ZHANG Jie, CHEN Chao et al. Study on the mining pressure law of the fully mechanized caving face in Jianbei Mine [J] Journal of Xi'an University of Science and Technology, 2014, 34(2): 142-146.
[6] Li Pengda, Wang Shunli. Observation and analysis of mine pressure law in fully mechanized caving face of Huangyuchuan Coal Mine [J] Coal Technology, 2014, 33(10): 180-182.
[7] Li Bingfeng, Zuo Yujun, Chen Zhao et al. Research on prevention and control scheme of mine pressure dynamics in 705 working face of Baojishan Coal Mine [J] Coal Technology, 2015, 34(08): 1-3.
[8] Lan Xueqiang, Wang Shixian, Jiang Lei. Observation and analysis of initial pressure on the top of the 1121(1) fully mechanized mining work in Zhangji Mine [J] Coal Technology, 2015, 34(2): 101-103.
[9] Song Baichao, Fu Yongzhi. Reform practice of downdraft ventilation of a fully mechanized caving face in Yannan Coal Mine [J] Modern Mining, 2014, 5: 112-114.