

New Progress Made in Huainan Mining Area CMM Extraction Technologies and Options of Emission Reduction and Utilization

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Abstract: Huainan mining area is an old mining area with mining history for a hundred years. With the mining depth increasing, CMM increases by a big margin, bringing about more and more threaten to the coal mine safety. For the purpose of coal production safety, efforts have been made for many years by Huainan mining area engineers and technical staff in CMM research and exploration. A set of methodologies of CMM prevention and treatment which is suitable to the local conditions and meets the requirement of Huainan coal production safety has been found out. Drained methane has been put into use, reducing the GHS emission and achieving the goal of environment protection. There is much in their method that similar mining areas can make use of.

Key words: Huainan Mining Area, CMM Extraction, New Progress, Emission Reduction and Utilization

Huainan mining area is an old mining area with mining history for a hundred years. With the mining depth increasing, the mine methane hazards are becoming increasingly severe. Since 1998 a technical study on comprehensive mine methane prevention and treatment has been carried out in the mining area. Critical progress has been made in roof methane extraction of the mining seam, preventing coal and mine methane outburst and other technologies. The mine methane extracted from 10.24 million m³ in 1997 has increased to 107.96 million m³ in 2002. The methane extraction rate has increased from less than 2% before 1997 to 31% in 2002. The frequency of outburst happening has decreased from 3.69 times/a before 1998 to 0.75 times/a. Severe methane accident has been stopped, relatively stabilizing the situation in the mining area's coal production safety. In 2002 the mining area raw coal output was up to 23.36 million tons achieving huge social and economical results. Meanwhile, drained methane has been put into use, reducing the GHS emission and achieving the goal of environment protection. Following is a brief overview of what we have been done over recent years.

1. Basic situation about Huainan mining area

Huainan mining area is located in central area of Eastern China, the north and middle part of Anhui province covering two cities Huainan city and Fuyang city. The mining area is 100 km long from west to east. The width from south down to the north is approximately 30 km covering an area of 3000 km². The mining area mainly contains the Huainan old area in the southern bank of Huaihe river and the Panxie mining area in the northern bank of Huaihe river. The mining area is 100 km to the capital city Hefei, 250 km to Nanjing city and 500 km to Shanghai city. Huainan coal mines have mining history for over 90 years, which was one of the national 5 largest coal mines.

The mining area has abundant coal resources. The proven coal reserves above – 1000 m is approximately 20 billion tons, of which 13.8 billion tons of reserves will be developed and utilized

during the planned period. There are about 30 billion tons of reserves above – 1200 m and 50 billion tons above – 1500 m. Total reserves account for 74% of the coal reserves in Anhui province, and 50% of those in Eastern China. Coal quality is very nice mainly gas coal and 1/3 coking coal. Coal here is characterized by extremely low sulfur (<0.5%), low phosphorous (<0.05%), nice coking property and strong coking property, which is high quality power coal. There are also abundant coal associated coalbed methane resources. According to the calculation and estimate, Huainan mining area has 592.825 billion m³ of coalbed methane resources. The CBM resource abundance is over 142 million m³/km², especially in Xieli area the coalbed methane is the most abundant with reserves up to 109.6 billion m³. CBM abundance is 405 million m³/km².

Huainan Coal Mining Industry (Group) Co. Ltd. is a state-owned exclusive investment firm which was re-structured from the former Huainan Coal Mining Administration. It is one of national 520 large sized enterprises and one of 17 key enterprises in Anhui province. The Group Co. Has 6v operating coal mines and 3 coal industry companies with design capacity of 22.25 million tons/a. The confirmed production capacity is 25.10 million tons/a. Except for Zhangji Mine which is a high gassy coal mine, others are coal and gas outburst coal mines. In 2002, 23.36 million tons of raw coal was produced ranking the fourth in the national same industry, the third in underground coal mines. The absolute methane emission is as high as 660 m³/min ranking the second all over the country. Huainan mining area belongs to severe gas hazard mining areas. In the mining history severe and worst gas explosion accidents took place frequently, especially in 1997, two worst gas explosion accidents happened within the period of less than 2 weeks, 133 people were killed causing heavy losses. It is estimated that raw coal output will reach 28 million tons by the year of 2003. With mining depth and mining intensity increasing, mine methane will increase to large extent.

2. Major technologies and methods for CMM extraction

For the purpose of coal production safety, efforts have been made for many years by Huainan mining area engineers and technical staff in CMM research and exploration. A set of methodologies of CMM prevention and treatment which is suitable to the local conditions and meets the requirement of Huainan coal production safety has been found out. Major technologies and methods are as follows:

2.1 Technology of CMM extraction in the roof of the mining seam

The methodologies for this technology is to drill CMM extraction boreholes or make a tunnel to the gob area above the working face roof. The drilling will be started from the main gate side of the working face. The purpose is to drain mine methane emitted from gob areas and adjacent seams due to mining operation and pressure reduction. Key issue of this technology relates to the law of the roof rock movement of the gob area, the gob area gas deposit and how will the gas move as well as the extraction technologies and process to be used.

This method uses multi-porosity flow theory, “O” loop theory on roof rock cave-in to develop and explore the gob area gas deposit and its moving law and flow field in fractures of the overburden rock layer. Through the computer value simulation calculation for the calculating

model of the working face inclined direction, fractures generation, growth, fracture zone height and limits of the working face, fractures of the overburden rock layer above gab areas have been analyzed and studied.

Beginning from 1998, the roof drilling CMM extraction experiment was carried out in Panyi Mine, Pansan Mine and other coal mines one after another. Roof tunnel method to drain gas was tested in Liyi Mine, Xinzhuangzi Mine, Xieyi Mine and Xie'er Mine. The application results indicate that after this technology is implemented, methane amount in the returning ventilation flow is reduced. Compared to the method that merely uses ventilation tail gate to discharge gas, the coal output from the fully mechanized working face is doubled.

2.2 Protection layer mining technology

2.2.1 Upper protection layer outburst-proof technology in a group of coal seams overlap mining
Huainan mining area is a mining area that has many groups of coal seams. For instance, XinZhuangzi Mine has many group of coal seams, of which there are B8, B7b, B7a, B6 and B4 five coal seams. The coal seams space one another is very close. Coal seam inclination is $28^{\circ} \sim 32^{\circ}$. In the course of coal mining, coal will be mined based on the mining schedule in the group of coal seams. Seam B8 which is no outburst hazard will first be mined. Then underlying Seam B7b, Seam B7a and the outburst seams B6 and B4 will be mined one by one. The study results indicate that after Seam B8 is mined the gas pressure of Seam B6 which is outburst coal seam is going down rapidly. The expansion deform was up to 27.1 ‰. Coal seam permeability increased. The permeability of Seam B4 increased by 20 times. The borehole gas flow rate increased by 16 times. The gas pressure reduced from 3.6 Mpa to 2.0 Mpa. After Seam B6 is mined, the gas pressure of Seam B4 reduced. Coal seam permeability increased. Borehole gas flow rate increased. The test results indicates that after Coal Seam B8 is mined, outburst hazard of Seam B6 and Seam B4 within the protection scope has been eliminated.

2.2.2 Tehnololgies on coal mine methane comprehensive treatment for long distance dip at low angle lower protection layer mining

The average space between two coal seams Panxie new area's Seam C13-1 and Seam C11-2 is around 77 m, of which Seam C13-1 is outburst seam. The underlying Seam C11-2 is non-outburst seam. In order to eliminate outburst hazard of Seam C13-1, a test extraction was carried out in Pansan Mine, i.e. first mine the coal of lower level fully mechanized No. 17151 (1) working face to liberate the fully mechanized working face No. 1781(3) of the protected layer.

After No. 17151 (1) working face is mined, there is no big gas emitted and outburst accident happened during tunneling operation in No. 1781(3) working face. The tunneling footage of the protected Coal Seam C13-1 increased from 60 m/month or so to 200 m/month. Because the outburst hazard has been eliminated, the coal cave-in method is allowed to use. The output of No. 1781(3) working face will be increasing from 600,000 ton or so to more than 1.6 million tons.

2.3 Technology on gas extraction with tunneling operation for outburst seams

Because of the fact that during tunneling operation coal cave-in would cause large amount of methane gas unexpected emission and coal and gas outburst likely lured, a study on the

technology related to gas extraction with tunneling operation was performed in the mining area. The method is to construct drilling site on two side walls of tunneling workings. In the drilling site longholes along the tunneling direction are drilled to drain methane gas. Meanwhile, short boreholes are drilled along the tunneling direction to drain methane gas. The method of gas extraction with tunneling operation can effectively explore faults and other geological situation ahead of working face, which is favorable to accurately take necessary measures in time to prevent outburst accident so as to avoid gas outburst accident to happen. This method not only solved the problems of outburst precaution for outburst coal seam and methane concentration beyond limit after blasting, but also provide a new gas pre-drainage method, which is a critical measure taken for methane gas precaution.

2.4 Cross measure pre-drainage technology

The method of cross measure gas pre-drainage requires that a coal seam or a group of coal seams have bottom workings. Drilling site will be constructed in the bottom workings. Cross measure boreholes will be drilled from the drilling site to the target coal seam or a group of coal seams. Each borehole will entirely penetrate coal seam or a group of coal seams. When No.4232C13 gate tunneling working face in Xie'er Mine goes through the cross measure pre-drainage zone, monthly tunneling footage was 35 m ~ 45 m. However, when going through the zone without gas pre-drainage the monthly footage only 20 m. And borehole gas spouting and drilling rod stuck happened quite often, which shows that the cross measure pre-drainage took certain effect.

2.5 Comprehensive precaution technologies for outburst coal seam to eliminate outburst hazards

Value analysis method was used to identify the reasonable parameter of borehole lay-out in the coal seam to eliminate the coal seam outburst hazard. Industrial test has been conducted in Xie'er mine. Due to use of the outburst eliminating technology of gas pre-drainage along the seam, the working face has achieved the entire coal seam cave-in coal mining when going through the pre-drainage zone. Compared with the mining method that a single seam is divided into several layers to extract, work load for mining preparations was saved. Productivity was raised. Apparent economic results have achieved.

2.6 Technology on pre-draining CMM of mining impact zone through surface wells

The technology of pre-draining CMM of mining impact zone through surface wells was used. Industrial test was carried out in Panyi Mine eastern area. The maximum gas output from the surface single well was up to 22190 m³/d. During the test period of 95.1 days, totally 1,225,207 m³ of methane gas was extracted. Daily single well gas production on the average was up to 14943 m³/d. When protected seam mining was ended, the surface wells can be taken as gob area gas extraction wells.

3. Existing extraction system and forecast for methane gas to be extracted

3.1 Existing main extraction systems and gas extraction in recent years

3.1.1 Existing main extraction systems

To assure coal mine safety, the mining area began in-mine gas extraction from 1960s. Several hundred RMB was invested having established 9 surface gas extraction stations, several 10,000

long workings, pipelines and boreholes. Totally 21 water ring vacuum pumps were installed, of which 3 pumps are medium sized pumps with rated displacement 67 – 82 m³/min, 7 pumps are large sized pumps with rated displacement 120 – 137 m³/min and other 11 pumps are large sized pumps with rated displacement larger than 180 m³/min. The designed extraction capacity is 687 million m³/a. If calculated on the basis of the extraction methane concentration 35%, 240 million pure methane will be extracted.

3.1.2 Methane gas extraction in recent years

Methane gas extraction in recent years is as follows: 6.6 million m³ in 1996, 10.45 million m³ in 1997, 22.60 million m³ in 1998, 37.60 million m³ in 1999, 49.40 million m³ in 2000, 71.05 million m³ in 2001, 107.96 million m³ in 2002. With new shafts construct one by one, and scientific and technical research improved and management strengthened, and the extraction method improvement, annual methane extraction is expected to increase to a large extent.

3.2 Prediction of gas extraction amount

3.2.1 Development Strategy of the Group Co.

Currently the Group Co. has made the development strategy “Build large Coal Mine, Set up Big Power Station and Make Capital”. And the “Mining Area Comprehensive Development Plan” has been worked out. The coal industry development leading policy has been identified, i.e. relying on the economic zone in eastern China and facing to two markets of domestic and international market, fully make use of superiority that Huainan Coal Industry Group Co. possesses such as abundant coal reserves, high quality coal, nice variety of coal, short transporting distance, good location, nice transportation facilities and rapid economy growth. And fully make use of the enterprise’s existing superiority in coal production capacity, marketing, dominant know-hows, huan resources and management, and other superiority, develop good points and get rid of shortcomings, make use of advantages and get rid of disadvantages to lay a foundation for the purpose of making the enterprise bigger and stronger. The planned overall target is as follows: implement the concentrative strategy for the dominant coal industry, make the enterprise bigger and stronger, and make the coal industry develop rapidly. It is planned that by the year of 2020 Huainan Coal Industry Group Co. will be built as a super large sized coal enterprise with annual raw coal output 100 million tons, meanwhile, build power station facilities with installed capacity of 20000 MW making Huainan Coal Industry Group Co. become a world-class coal, power and energy production base. The plan will be implemented in two steps: the first step, with technical retrofit and reform being done for the existing operating coal mines, construct a group of safety and high efficient coal mines: Zhangbei, Guqiao, Dingji, Pansi, Zhuji and Wangfenggang coal mines making the mining area’s production capacity reach 70 million tons by 2010. The second step, with deep coal seam mining technologies and gas treatment approaches constantly improving, it is planned to build three deep shafts: Panyi, Pansan and Guqiao deep shafts. Combined with coal mine retrofit and extending, the mining area’s production capacity is expected to reach 100 million tons by the year of 2020.

3.2.2 Comprehensive methane precautions

With coal mine production going up constantly, mining site will gradually move deeper. Methane abundance will be increasing by a big margin from the current level of 660 m³/min. It is estimated

that by 2007 methane abundance of the mining area will reach 1000 m³/min. The existing 9 coal mines will become outburst coal mines. Existing methods and approaches for methane treatment can not suit the requirement for the future development of the mining area. In order to assure the national safety production regulations to be carried out and long-term development of the mining area, the Group Co. has drawn up a plan from 2003 to 2007 for existing coal mines methane comprehensive treatment, and planning to prevent and utilize methane gas for newly built coal mines.

3.2.2.1 Major strategic idea

- (1) Strengthen tackle key problems. The goal is to eliminate big and heavy gas accidents. Coal mine development and mining should be conducted in a reasonable way.
- (2) Aiming at the key problem: prevent methane outburst, strengthen the concept “carry out gas extraction before coal mining, coal mining capacity will be associated with gas extraction capacity, balance the gas extraction and mining”. Take comprehensive CMM extraction as main approaches for the methane gas treatment.
- (3) Summarize CMM treatment technologies and scientific research results. Provide the mining area with experiences to fully disseminate CMM treatment approaches.
- (4) Set up the strategic concept of “Turn wastes into treasure”. Take the measure of reduce seam pressure through gas pre-drainage. Develop and utilize clean energy. Establish the national biggest methane gas development & utilization demonstration base.

3.2.2.2 Planned tasks

Retrofit the ventilation system of production coal mines, extend the ventilation capacity, eliminate high negative pressure system and replace old ventilation fans.

By means of science and technologies to promote development of coal industry. Strengthen input for methane gas scientific research. Build methane scientific research institutions (a methane and geological research institute has been established). Vigorously unite scientific research institutions and universities to adopt effective measures to explore methane deposit law so as to provide reliable geological conditions for reasonable mining development. Strengthen theoretical research on methane abundance law. Make control of the methane abundance within the safe limits to eliminate gas accident.

Methane gas scientific research will focus on tackle- key- problem projects in the period of “Tenth Five Year Plan”. Input more funds and focus on deep part of existing coal mines to explore methane deposit law in deep part of the coal mine, find out what area should be mined first and when to mine other areas one after another. Find out the law of seam pressure reducing and methane source, and other gas abundant laws. Adopt relevant measures of ventilation, gas drainage and extraction for the safe mining of deep part coal seam.

Intensify and carry out measures of “carry out gas extraction before coal mining, coal mining capacity will be associated with gas extraction capacity, balance the gas extraction and mining”, which is critical issue to comprehensive prevent and utilize methane gas. With the method of gas extraction before coal mining being carried out, summarize the extraction experience and results.

Further improve roof methane extraction technology in low gas area. Keep using special roof workings for gas extraction to increase extraction amount. Extend the capacity of gas extraction station of the coal mine. In high gassy area entirely carry out “gas extraction before coal mining”. Make detailed plan for coal mining in liberated seams. Make use of low gassy coal seam and weak outburst seam to liberate high gas hazards of high gassy coal seam and high outburst coal seam. In this way coal seam productivity can be promoted. Therefore raise efficiency of personnel and equipment achieving safety and high efficiency so as to improve the safety situation in the mining area.

Explore technologies on extracting methane from pressure reducing zone by using surface wells. For coal mines under construction, sufficient capacity of gas extraction system will be built to match the coal mining capacity so as to avoid the retrofit and extension.

3.3 Forecast of methane extraction

It is predicted that the mining area's methane extraction amount is as follows: the methane extracted will reach 120 million m³ by 2003, 150 million m³ by 2004, 180 million m³ by 2005, 200 million m³ by 2006, 220 million m³ by 2007, 300 million m³ by 2010 and 500 million m³ by 2020.

4. Options for methane emission reduction and utilization

4.1 Currently methane utilized

Since 1974 the extracted methane has been used as industrial and domestic fuel. In 1986 two gas holders were set up in Xieyi and Xie'er coal mines one after another. The gas holder capacity is 10,000 m³ and 30,000 m³, respectively. Pipeline and other associated facilities were also established. Methane extracted has been utilized as resident fuel of the two coal mines. Annual methane consumption is 5 million m³. In 2000 two coal-fired boilers were reformed as gas burning boilers in Xie'er Mine. The 2 boilers consume approximately 3.5 million m³ of methane gas annually. The whole mining area reduced emission and utilized methane up to 8.5 million m³. The utilization rate is 7.9 %.

4.2 Methane emission reduction and utilization engineering projects under construction

At present, two gas holders with capacity of 30,000 m³ of each is in construction, respectively set up in Panyi and Pansan Mines. Related pipelines are also under construction. It is estimated that by the end of the first fourth of the year 2004 it can be put into use. In this way the annual methane emission reduction and utilization will reach 15.8 million m³.

Additionally, Xieqiao Mine is constructing 2×800 kw power generation units. And it will start producing electricity in June. Annual methane emission reduction and utilization will be 8.53 million m³.

After the above engineering projects are completed and put into use, added with 29.33 million m³ of methane emission reduction and utilization from the boilers reformed, the utilization rate will reach 24.4%.

4.3 Options and target of methane emission reduction and utilization

Started from 2004, we will be planning to retrofit totally 14 boilers with capacity 4 tons each in 7 coal mines Panyi, Pandong, Pansan, Zhangji, Xieqiao, Xieyi and Xinzhuangzi Coal Mines. All the boilers will use gas as fuel. In addition, a gas power station of 2×1000 kw will be set up in Panyi Mine Dongfeng Shaft, Pansan, Zhangji, Xieqiao and Xinzhuangzi Mines, respectively. Additionally, retrofit the surface utilities used for gas extraction to make these facilities burn gas. The entire engineering projects will be completed before 2007. At that time boilers will burn 65.80 million m^3 of methane. Power stations will consume 53.20 million m^3 of methane. Surface utilities will burn 4.75 million m^3 of methane. Thus, newly increased burning and emission reduction and utilization methane will be up to 123.75 million m^3 , added with 29.33 million m^3 of methane which has been reduced emission and utilized, by the year of 2007 total methane reduced emission and utilized will reach annual 153.08 million m^3 . The emission reduction and utilization rate will be up to 69.58%, which is equal to reduce emission to the atmosphere 3.89 million tons of CO_2 .

With Methane extraction going up rapidly, in addition to retrofit the existing boilers and build power stations, some gas chemical projects are planned to build. The overall target is to achieve the emission reduction and utilization rate 90%.

5. Conclusion

5.1 Coal mine produces large amount of methane gas during coal mining operation. Methane is a combustible and explosive gas. In the history many coal mine methane explosion accidents happened in Huainan mining area. Many miners were killed in the accidents. The accidents also caused heavy economic losses. Therefore, for the purpose of coal mine safety, it is necessary to extract methane gas. Additionally, it is needed to input more science and technologies and capital to do the research of more advanced extraction method and technologies, equipped with more advanced equipment and facilities. And improve existing systems to meet the requirement for safety production.

5.2 Methane gas is an associated resource produced with coal mining. Meanwhile it is also an important greenhouse gas that is 20 times more potent than carbon dioxide. Its emission to the atmosphere will result in global climate warming. Therefore it is necessary to reduce methane emission and make use of it to meet the requirement for the environment protection.

5.3 Methane is not only a harmful gas but also a clean energy. It is a big waste of resources that methane gas is not comprehensively utilized. Methane comprehensive utilization conforms to the state industrial development plan and is beneficial to coal production safety, the improvement of energy structure and reduction of atmosphere pollution. Meanwhile, it will obtain nice economic and social results.

5.4 Large amount of money is needed for developing projects relating to methane emission reduction and utilization, strengthening tackle key problems for methane extraction technologies and replacement of equipment and improvement of extraction systems. It is recommended that the government make relevant preferential policies to support and assistant in methane emission reduction and utilization.