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THE PRESENT SITUATION, PROBLEMS AND COUNTERMEASURES TO DEEP MINING IN HUAINAN AND HUAIBEI COAL MINING AREAS

1. The situation and problems of deep mining in Huainan and Huaibei Mining Areas

Anhui Province, located in the southeast of China, the geographical position is longitude 115°–119°40' and north latitude 29°26'–34°40'. The total area is 139000 square kilometers. The coal resources of Anhui are mainly distributed in Huaibei Coalfield and Huainan Coalfield (Huainan and Huaibei Mining Areas), Carboniferous, Permian coal-bearing strata, followed by the Wannan Coalfield, distribution in the area on the southern side along the Yangtse River. The coal bearing area in Anhui Province is about 1800 square kilometers, which account for 12.9% of the total area of the province. Coal reserves in the province are 273.585656×10^9 tons, in which coal reserves for coal mines in production and construction are 87.466289×10^9 tons, the reserves for the further exploration are 115.891987×10^9 tons. Predicted reserves are 61.15551×10^9 tons, in which reliably predicted reserves is 32.18962×10^9 tons. In Anhui Province all kinds of coal occur, from low metamorphic coal to high rank anthracite.

Coal gas occurrence conditions and its influence on coal production. 98% coal resources in Anhui Province gathered in Huainan and Huaibei Mining Areas. Geological exploration data shows that geological structure in Huainan and Huaibei Mining Areas is complicated. Coal seams are multiple and buried at great depth. Exploitation entered into deep mining (mining depth of 600 meters and above), coal rocks are soft, coal seams have low permeability (most of them below 0.01 mD), gas content is high ($10\text{--}36 \text{ m}^3/\text{T}$), gas pressure is high (2–3 MPa, at great depth more than 6 MPa), coal seam spontaneous combustion period is short, the danger of coal dust explosion is high, forming thick alluvium, high gas, high pressure, high temperature, so called “one thick three high”. Huainan and Huaibei Mining Areas are

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one of the most complicated mining areas in China of mine gas control. Based on gas danger ranking result analysis in the recent years, in Anhui Province gas emission increases 100–200 m³/min per year, producing every 1 t coal discharge gas of 9–11 m³. In Huainan and Huaibei Mining Areas there are 4 state-owned coal mining enterprises, which have 50 mines. Among the mines 12 high gas mines and 29 coal mines with threat of coal and gas outburst. Gas emission quantity from 49 mines is 2133.41 m³/min. Gas emission from mines of Huainan Mining Group accounts for 52% of the total gas emission from coal mines in Anhui Province.

2. Comprehensive management measures to the problems of “one thick three high”

2.1. High gas comprehensive control measures in Huainan Mining Group as an example

Huainan Mining Area is located in the middle-north part of Anhui province, with 28.5 milliard tons of coal resources approved by the national government for mining, is the largest equipped coalfield in reserves on the south to Yellow River, which has the most potential for development. It is one of the 13 coal production bases with annual output of hundred million tons of coal, and one of the 6 large coal-electricity bases. Huainan Mining Group has 13 coal mines in production and 2 coal mines in construction, 72000 on-the-job employees. In 2010, raw coal output is 661.9 million tons.

In Huainan Mining Area coal seam occurrence conditions are very complex, is the typical mining area of exploitation under conditions of high gas, high strata stress and high temperature. Coal seam gas resources are 600 milliard m³. Coal seam gas content is 12–36 m³/t. In 2010, absolute gas emission is 1332 m³/min in the mining area. In 13 production mines, there are 12 mines with threat of coal and gas outburst, 1 high-gas coal mine. Huainan Mining Area had historically been a gas accident-prone area. From 1980 to 1997, 17 gas explosion accidents occurred, in which 392 miners died. Learn from their mistakes, Huainan Mining Group established a comprehensive gas control system, and found out coal mine gas prevention and control measures with the characteristics of Huainan Mining Area. In the 13 consecutive years gas explosion accidents have been eliminated, and the gas control method becomes a model for coal mine gas control in China.

2.1.1. Establish active and comprehensive gas prevention and control philosophy

In order to radically control gas, protect employees' lives and safety, realize healthy development of enterprises, the philosophy of gas control must be changed. The philosophy was proposed, which including: gas overrun is an accident; Gas is the harm and also a treasure; Change passive gas drainage into active gas extraction, gas extraction ensures gas supply

for utilization, and gas utilization promotes gas extraction, co-mining of coal and gas is realized; Pay equal attention to gas control and gas utilization, change waste into treasure; Wherever with the conditions protective seam exploitation should be performed; Gas possible for extraction should be extracted as much as possible. The principle must be implemented: “coal seam exploitation after gas extraction, gas monitoring and control, coal output according to air flow supply”. Mining operations should be conducted when high gas state in working faces is changed into low gas state by stress-relief extraction. Require gas concentration reached 0.8% cuts off power and ensure the results from monitoring and control system are true, accurate and reliable. Arrange production according to the ventilation and extraction capacity, to ensure that gas concentration is not overrun.

2.1.2. Build efficient gas control system

An efficient organizational structure of gas comprehensive control was established. The major policy of gas control measures is determined on the working meeting of board of directors and general manager. The persons in charge of safe production and technology are responsible for day-to-day management. Chief Engineer is in charge of managing director and managing deputy general manager, leads technical work of production safety, implementation of economic integration of safety in production technology, institutionally performances coherence between safety and production. The Institute of Gas Geology Management was set up at first in the entire industry, which combines gas control and geological research, pays equal attention to management and research. The Special Laboratory of Gas Control and Utilization, and Gas Control Steering Group were established. the professional gas control team for drilling, extraction, coal seam discovering in roadways was set up.

Ensured capital investment for gas comprehensive control. From 2005 to 2007, coverage for safety had been ensured according to 33 yuan RMB per ton of coal sold and from 2008 according to 55 yuan RMB per ton of coal sold, in which 70% for gas control, 15% of total costs. By adequate funding, gas control system, engineering and facilities were built, speeding up upgrading of gas control equipments. From 2002 to 2010, the total capital investment by the Group for technology research and development of gas control and utilization, renewal of equipments, materials and associated engineering and other aspects, reached 13.9 milliard yuan RMB.

Focus on improving the personnel comprehensive qualification in gas control. The Group Company vigorously employed gas control professionals, more than 1,800 graduates from more than 100 universities across China and more than 90 gas control professionals with master degree or above degree were employed. 280 professionals and technical personnel were trained in-service. Safety training center was set up, gas control experts are invited to train professionals and technical personnel on a full-time once every 2 years, in order to improve basic knowledge of gas control. Focus on the shaft leader's team construction and implementation of dynamic replacement with assessment; all personnel working underground in mines take full-time training in gas control not less than one week per year. Innovate gas control key technologies, implement the key technologies, such as stress-relief gas extraction,

integrated coal exploitation and gas extraction without pillars supporting, three-dimensional gas extraction under conditions of multi-seam exploitation, deep low-permeability coal seam uncovering, which lay a solid foundation for safe and efficient mining of coal seams with complex geological conditions, high gas or outburst threat.

2.2. Comprehensive control measures of high strata stress

Mining depth in most of production coal mines in Huainan and Huaibei Mining Areas reaches or exceeds 600 meters, mining depth in newly-built mines more than 800 meters, most of roadways in soft rocks, with large stress and big displacement, displacement of roof, floor and roadway sidewalls reaches about 800÷1500 mm, which make support and maintaining of roadways in particular mining and preparation roadways extremely difficult. The following measures are taken in Huainan and Huaibei Mining Areas to resolve the problems of high strata stress:

Classification and analysis of roadway surrounding rock deformation is carried out, in order to effectively control surrounding rock deformation, and be convenient to engineering applications. The main purpose of roadway support is to control large deformation of roadway and prevent rock caving in the fissures circle, and limit expansion scope of fissured spheres, to improve its stress state and enhance its own residual strength and bearing capacity.

Shed support is by using shed to give radial pressure to surrounding rocks, which can change the radius of the fracture circle, and range of plastic spheres, because it acts on the entire plastic spheres and cracks circle in rocks, it directly balances the original rock stress. Therefore, a large support force is required in order to achieve the desired supporting effect.

Bolt support only gives radial force to the rocks in bolted range. The bolted range typically includes cracks and part of the larger plastic deformation range of plastic spheres. Rocks bolted in the bolted layer will return to the state of repeated loading flexibility, the ultimate stress at the moment is residual strength. This kind of state keeps stability of fractured spheres. Required force by using bolt support is much less than by using shed support. Therefore, in deep mines roadway support by bolt and by compound supporting system with bolt is widely and successfully applied.

In deep underground mining, due to small choice of mining roadway location and great impact of mining stress, deformation of mining roadways is the most serious, or even destroyed, seriously affecting production in working face. Mining roadways located in the region of low stress and implementation of non-pillar mining are the most fundamental measures for mining roadways in well-maintained state. In deep mines, mining roadways should be supported by active support system to take full advantage of the surrounding rocks own strength and self-supporting ability. The bolt joint supporting system such as bolt-net-spray, bolt-net-spray-rack, bolt-net-cable-spray, is an effective supporting way. Cable support structure is simple, and construction is flexible, which can be used with various supporting systems. Its length can be determined according to the actual needs, so it can reach the deep relatively stable rock formations, and can exert a considerable prestress. This kind of support in deep roadway support plays an effective role, which is worth promotion. However, great importance

should be attached to selection of cable bolt supporting parameters and construction technology; otherwise it would be difficult to achieve the required supporting effect. In deep mines, one of the effective measures to prevent floor heave is to control the roof and sidewalls of roadway. The roof effectively controlled, sidewalls displacement decreased, heave is correspondingly decreased. Grouting surrounding rock can be used in very difficult areas to support.

2.3. Comprehensive control measures of high temperature

In Huainan and Huaibei Mining Areas in coal mines of the four mining group companies high temperature occurs, geothermal gradient per 100 meters is 2.5–3.8°C. High temperature in mines of Huainan Mining Group is most serious, in Dingji Coal Mine rock temperature is up to 43.13°C, causing miners' physical decline, sometimes syncope, which seriously impacts on production safety. In view of this situation the following measures are adopted:

- 1) Strengthening ventilation management. Strengthen ventilation facilities management, ensure ventilation safety and reliability;
- 2) Equipping local refrigeration equipment. In working face of high temperature install local refrigeration equipment, achieve temperature requirements;
- 3) Equipping personal protective equipment. Wear personal protective clothing;
- 4) Establish surface or underground centralized cooling system. By introduction and innovation of cogeneration technology of gas power generation and refrigeration by waste heat, the first in Asia gas power station with centralized cooling system by waste heat was built;
- 5) Supplying personal protective equipment. Supply mineral water, Rendan and other cooling supplies. Creating a safe working environment, ensure health of miners.

2.4. Shaft construction technology in thick alluvium

In the new development part of Huainan and Huaibei Mining Areas, alluvium is thick, reaches a thickness of 200–450 meters, which contains more than 10 laminar sand. In view of this condition the following measures are adopted: design large mines with an annual output of 8 million tons and above; vertical shaft multi-level development; in thick alluvium apply freezing shaft sinking.

3. Conclusions

The condition of thick alluvium, high gas, high stress and high temperature, is the natural existence, which must be faced. According to many years of production experience, positive and comprehensive management concept must be established.

In Huainan and Huaibei Mining Areas coal seams occurrence condition is very complex. In each mine, each mining level, each wing of each mining level, each district, even different sections of each district, the “three-highs” are somewhat different, must be comprehensively analyzed, scientifically treated, and managed by classification.

Huainan Mining Group has built an effective gas control system, established an efficient gas comprehensive management organization, ensures the capital investment for comprehensive gas control, pays attention to improvement of personnel comprehensive qualification in gas control and so on a number of effective measures, for 13 consecutive years gas explosion accidents have been prevented, which becomes a national example in coal mine gas control. In the achievement strict management is the most important.

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