An Interdisciplinary Response to Mine Water Challenges - Sui, Sun & Wang (eds)

Optimization Utilization Projects of Limestone Water in Hengyuan Coal Mine

Dayong Wei, Benkui Sun
Hengyuan coal mine， Huaibei 235162
Hengyuan coal-electricity group corporation, LTD， Suzhou 234000

Abstract It is often found that the surface subsidence due to the excessive groundwater drawing from the unconsolidated aquifers in the Quaternary makes contributions to the shaft fractures in the Huaibei coal area. Hengyuan Coal Mine is one typical example. This paper investigates the hydrogeological condition and the defects of the present groundwater utilization projects. After that, the new water discharging and supply program that uses the Taiyuan formation limestone aquifer instead of the unconsolidated Quaternary aquifers is proposed, and afterward it's proved feasible and effective. The new project is helpful to gradually slow down and decrease the surface subsidence, and prevent from the shaft fractures and keep the mining safe. Also it makes the use of groundwater resource perfect.
Keywords Taiyuan formation limestone aquifer; quaternary unconsolidated aquifer; surface subsidence

Hengyuan coal mine of Sui-Xiao mining area locates in the Midwest of Huaibei coalfield. It went into production in 1993, and the current production capacity is about 2 million tons every year. Now, Hengyuan coal mine is mining both of the NO.4 coal in the Shihezi formation and NO.6 coal in the Shanxi formation. In the mining of NO.6 coal, one of the threats to safety is from the Taiyuan formation karst fractured aquifer in the upper of Carboniferous. The Taiyuan formation aquifer consists of 12 thin limestones, of which the NO.3 and NO.4 have better water abundance and their values of '*q*' range from 0.23 to 1.0 L/s·m. Some measures are taken to keep the safe production, including grouting to the limestone aquifer and improve its strength, and discharging the groundwater and reduce its water pressure. Currently, the total water inflow is nearly 470 m^3/h, of which respectively about 170 m^3/h from the discharging and 300 m^3/h from the mining. On the ground, the coal mine has 14 wells to draw groundwater as domestic and power plant water from the NO.2 and NO.3 unconsolidated aquifers in the bottom of Quaternary, both of which have good water supply from the precipitation and their values of '*q*' range from 0.1 to 0.6 L/s.m. The disadvantage results due to the groundwater drawing have great impact on the safe production, including the surface subsidence over 380 mm in the industrial square and auxiliary shaft fracture. In addition, the low utilization of mine water results in serious waste of valuable groundwater resources, and the contaminated mine water discharged to the ground ditches could contaminate the surface environment. Therefore, the effective control on the groundwater exploitation and improving reuse of underground water are advisable and essential.

The present mine water resources utilization and its disadvantages

Taking account into the water supply and quality hardly meeting the demand, the Hengyuan coal mine has finished 14 wells to draw water from the Quaternary unconsolidated aquifers. Every well could supply water ranging from 30 m^3/h to 45 m^3/h. The consumed water up to 120 m^3/h are all from the wells including daily life, power plant and fire control. The water are transported into a 400 m^3 reservoir located in the industrial square, and then to the bathroom, washing room, dining room and power plant by the pressure pumps.

To decrease the groundwater pressure below the mining area, the GS9 drilling whose maximum capability is up to 170 m^3/h is always in the state of drainage of Taiyuan formation

limestone. At present the water are transported through the roadway into the underground sump, and then pumped up to the sewage treatment plants with the mining water. After some treatment , they are mainly transported to underground working area by some drillings, and the coal preparation plant and cooling towers of power plant, where the water consumption are respectively up to 100 m^3/h, 30 m^3/h, 160 m^3/h. In addition, 180 m^3/h mine water resources are still not effectively utilized and discharged to the ground ditch.

But long time and excessive drawing water from the Quaternary unconsolidated aquifers finally induces the surface subsidence which results in some safety problem including shaft fracture and some ground buildings cracking. Water resource wasted and environmental pollution problems due to the low utilization of mine water also have negative impact on the development of enterprises and society.

Optimum utilization of the limestone water

Optimization ideas

It is required to make full use of groundwater from the GS9 drilling as alternative daily water source, and stop drawing of most wells, just keeping the NO.2 well as a source of drinking water. These measures are taken to stop the surface subsidence, and gradually decrease the mine water emission to minimum.

Engineering design principles

Only the quality of purified limestone water meets the hygienic standard for drinking water (GB 5749-2006) of China, they can be used for bathing, washing, production, and drinking.

The water purification treatment systems can only locate in the existing industry square to reduce the project investment.

The water purification treatment systems should have good flexibility and adjustability to adapt the changes of water quality and quantity.

It is necessary to improve automation level of the water purification treatment systems to make the operation and management easy.

Optimize content

Limestone water quality analysis

Compared with the groundwater quality classification index shown in the table 1, the limestone water from the GS9 drilling are classified as the V, and can't be used for drinking.

Table 1 *Mine limestone table the results of water quality tests*

No.	Category Index	Testing Sample	Class IV groundwater(GB/T14848-93)	Drinking water standards(GB5749-2006)
1	Total Hardness	1058	550	450
2	Dissolved solids	2055	2000	1000
3	Sulfate	1082	350	250
4	Fluoride	2.26	2.0	1.0

Taking account into the limestone water quality parameters and sensory analysis, the desalination treatment is necessary. Only after that, the limestone water can be used for bathing, and supply the coal preparation plant and cooling towers of power plant .

Limestone water collection

A pool for the limestone water from the GS9 drilling is excavated to separate the polluted mining water. In addition, two MD155-67×7 type pumps are located around the pool and connected with the existing main draining pipeline (the diameter is 325 mm) in the auxiliary shaft to discharge the limestone water to another pool on the ground.

Limestone water purification

The water purification treatment systems for the limestone water are installed to make the water in the tank fine filtered and desalted. The quality of the purified water should strictly reach to the hygienic standard for drinking water (GB5749-2006) of China. The treatment capacity is up to 2000 -3000 m^3/d.

***Table** 2 List of limestone water treatment facilities*

No.	Project	Equipment capacity	Processing capacity	Working Hours	Nissan volume	Remark
1	Underground lifting	80 m^3/h	160 m^3/h	18 h	2880 m^3/d	Using two, one alternate
2	Limestone water pools	400 m^3				need to build
3	Original water pump	80 m^3/h	160 m^3/h	18 h	2880 m^3/d	Including Backwash
4	Desalination workshop	80 m^3/h	160 m^3/h	18 h	2880 m^3/d	75% water production rate, 90% salt removal rate
5	Clean water tank	400 m^3				done

The purification treatment systems are implemented according to some strict process. First, the limestone water are pumped into the '863' filters where about 95% suspended matter, and also the macromolecule organic compounds, virus, bacterial, colloid and iron compound could be effectively separated from the water. Then the preliminary treated water are purified in the precise filters so as to remove the very tiny particles before in the security filters. Second, the filtered limestone water are treated by reverse osmosis. Here, the reverse osmosis membranes play an important role in separating the inorganic ions, and the residual macromolecule organic compounds and colloid. Operating some time, the reverse osmosis membranes may be contaminated by the suspended matter and the insoluble salts, so it is necessary to do some clear to keep its normal operation. The specific chemicals are dissolved in the clear water and pumped into the clearing filter, then clear the reverse osmosis membranes. The chemicals from the reverse osmosis membranes are back into the clear water, and do the clearing again. It's a cycle until the clearing meets the requirements.

After purification treatment, as long as the quality meets the national standards, the purified water are pumped to the ground bathhouse, production buildings, office buildings, dormitories and power plant. The mining water (about 300 m^3/h) could be purified in the sewage treatment plants, and then used in the working faces, for the dustproof, and supply the coal preparation plant and cooling towers of power plant. The mine water emissions from the sewage treatment plants could be reduced about 180 m^3 / h.

Limestone water treatment engineering investment analysis

Engineering costs: the total costs is up to 2.78 million yuan which include 2.24 million yuan for the drill engineering equipment of the limestone water desalination treatment system, and 540,000 yuan for the civil engineering.

Operating costs: the total costs is up to 0.98 yuan/ton which consist of 0.15 yuan/ton for manual management, 0.45 yuan/ton for electricity consume, 0.27 yuan / ton for depreciation and 0.11 yuan/ton for maintenance and management. If the capacity of limestone water purification treatment is up to 2,200 tons per day, it can meet demand of the daily life consume and production. The limestone water purification treatment costs 780,000 yuan per year.

Benefit analysis

After all mine water purification reuse, zero emission standards, annual savings of 800,000 yuan mine water discharge fees , water wells exempt from groundwater abstraction costs 40 yuan, recyclable investment costs within seven years . The transformation can be closed ground 12 water wells , reducing loose layer abstraction 100 m^3/h, can effectively control ground settlement and eliminate the root cause of broken wall to ensure mine safety production, with enormous economic and social benefits.

Once the limestone and mining water are reused and the emission is to the minimum, it will economize 400,000 yuan per year for drawing groundwater and decrease the sewage discharge fees about 800,000 yuan per year. The costs can be recovered in 7 years. By decreasing the groundwater drawing from the Quaternary unconsolidated aquifers by closing 12 wells, it effectively control the surface subsidence, and weaken the induce of shaft fracture and make mining production safe. Moreover, it brings enormous economic and social benefits.

Conclusion

By the full analysis of the hydrogeological conditions and the disadvantages of current water supply and discharge of Hengyuan coal mine, an economy and effective optimization program is proposed that uses the purified limestone water instead of the unconsolidated Quaternary water. The new program is favorable to stop the surface subsidence and make mining production safe, also save the groundwater resource, and protect environment. It responds the current national energy conservation and recycling economy policies to promote the healthy development of the coal mine.