

Purify processing and utilization of mine water

S. Aijun, W. Shiwen*, Z. Liya

Hebei GEO University, China

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China is a large country of coal production. During the coal mining process, massive mine drainage has caused not only the waste of groundwater resource, but also environmental pollution. On the other hand, mining production and life supply water is very scarce. According to the mine water features, majority of mine drainage water belongs to the mine water containing suspended solids, the mine water needs to be necessarily purified before used. What the purification mainly eliminates is the suspended solids. In this paper, the methods and technological processes about mine water purification are discussed, such as coagulation, sedimentation, filtration and disinfection. Different ways of methods and technological processes have to be chosen according to different characteristics of water quality. Finally, examples on purification and utilization of mine water, such as Pingdingshan Coal Group Company, Wannian Coal Mine of Fengfeng Group Limited Company and Tangshan Coal Mine of Kailuan Group Company, are shown to prove the obvious social, economic and environmental benefits of mining water purification and utilization.

Keywords: mine water, purification, turbidity.

INTRODUCTION

China is a large country of coal production, raw coal production amounted to 10.79×10^8 t in 1990, and reached 21.1×10^8 t in 2005. It ranked the first in the world for many years [1]. Coal is the main energy source of China, accounting for over 70% of our one-time energy consumption. Chinese coal mainly comes from underground mining, accounting for about 97% of the overall coal production. As coal beds generally buried below the underground aquifers, in the coal mining process, people must discharge massive water inflow to ensure the mine safety. According to incomplete statistics, the drainage of whole national coal mine is approximately 22×10^8 t per year, and the average drainage is about 4 m^3 per 1t coal, but the utilization ratio is less than 20% [2-4]. The great massive mine drainage has caused not only the serious waste of groundwater resource, but also environmental pollution, on the other hand, mining production and life supply water is very scarce. In the mine area, industrial and agricultural supply water is also very scarce, a lot of mine drainage makes the contradictions between drainage and water supply more serious, and accelerated water crisis. As for the coal industry, 70% of the mining area in China faces water shortage, where 40% belongs to serious water shortage, and life supply water of many mining areas is very shortage [5].

With the economic and social development and the exploitation of coal resource, the contradiction between mine drainage and industrial, agricultural, life supply water also will become more and more highlight. Strengthening the new technique research and utilization of mine water purification can mitigate the water crisis, promote the economical continual development and protect ecological environment and so on.

Mine Water Quality Features

According to the mine water quality features, it can be generally divided into the following types [6]: (1) clean mine water; (2) mine water containing suspended solids; (3) high mineralization mine water; (4) acid mine water; (5) mine water containing special pollutants. In North China, most mine drainage belongs to mine water containing suspended solids.

Mine water containing suspended solids is the mine water in which the content of suspended solids (commonly expressed by SS) cannot be dissolved is very high. The general content of suspended solids is 100~500mg/L, sometimes over 1000mg/L. Therefore, the turbidity of mine water is about 100~300 degree. The suspended solids in the mine water are mainly come from coal fine, rock dust as exploitation activity generate into the mine water. Therefore, the mine water color shows dark, the sensory situation is very bad.

Under normal circumstances, mine water generally stay in the mine water storage for a period of time (generally 4~8 h), so larger pieces of coal granule, rock granule and other solid

* To whom all correspondence should be sent:
E-mail: wsw84946108@163.com

particles can be naturally deposited at the bottom of the water storage. Then, the drainage equipment pumps the mine water in the water storage to the ground. So the size of the suspended solids pumped to the ground is generally small, the diameters of majority particles are below $50\mu\text{m}$, moreover, the density of suspended particles are also small, the average density is $1.2\sim 1.3\text{g}/\text{cm}^3$, so its subsidence speed is very slow.

Another water quality feature of mine water containing suspended solids is that the bacteriological content is very high. Bacteriological indicators such as the total bacteria amount exceed the standard seriously, the colon bacillus often exceed the standard several times, or even thousands of times. This phenomenon is caused mainly by living, production activities under the mine well.

Mine water, especially the karst water, the original water is generally high quality groundwater, and belongs to HCO_3 or $\text{HCO}_3\text{-SO}_4$ - type water. The mineralization degree of water is generally smaller than $1\text{g}/\text{L}$. The total hardness is smaller than 25 German degrees. As the result of exploitation, the wall rock groundwater with massive mine dusts, stives, and rock debris pellet in different size flowing into the mine system, made the water quality bad; especially make the suspended content rise, the reproduction of the bacterium and the mildew increase quickly. The water is turbid and the feeling and seeing state is bad. Therefore, mine water needs to be carried on essential purification before used[7].

New Purification About Mine Water

Purification methods

All impurities in mine water may be divided into 3 kinds: suspended, colloid and solute. The main objects which the purification needs to remove are the suspended and the colloid impurity, which are the main reasons of leading to water turbidity.

The principal characteristic about suspended solids is that they often present in suspended state in dynamic water. But they may be separated in the hydrostatic water, light matters will float up, and heavy ones will sink down. The principal characteristic about colloid grain is that it is quite stable in the water, it will not naturally subside after a long time even several years. When light illuminates, it is scattered and causes turbid. According to the characteristics of the suspended and the colloids, the main methods of the purification for living water are coagulation, sedimentation, filtering and disinfection.

(1) Coagulation, it is an extremely important aspect in the water purification technology. In the process of purify the turbid water, it needs to add the coagulants. The principles of select the coagulants are they can produce large, heavy, strong vitriol flower, the effect of purifying water is good, and it has no bad influence to the water quality. Moreover, the price is cheap and the source of goods is sufficient. Simultaneously, we should select the coagulant according to the water quality characteristic and the water temperature of the water source and so on. The commonly used coagulants may be divided into two kinds. One kind is the aluminum salt coagulants, another is the molysite coagulants, such as aluminum sulfate ($\text{Al}_2\text{SO}_4\cdot 18\text{H}_2\text{O}$), iron trichloride ($\text{FeCl}_3\cdot 6\text{H}_2\text{O}$), ferrous sulfate ($\text{FeSO}_4\cdot 7\text{H}_2\text{O}$), polymerization aluminum chloride, and organic high molecular polymer flocculants. Among them, aluminum sulfate is the most widespread coagulant at present, and the second is the polymerization aluminum chloride.

The mixing process is to let the medicament solution disperse into the water rapidly and evenly. The coagulant selected should be mixed evenly with the original water in a short time, and enables the whole colloid impurity in the water to react with the medicament. At present, two methods are mainly used in majority water factories: the water pump mix and the pipeline mix. After a instant mix of water and the medicament, some tiny vitriol flowers can appear. In order to sink rapidly, they must be agglomerated into large sizes ($0.6\sim 1.0\text{mm}$), and close-grained, not frangibility. But in the coagulation stage, water turbulent motion intensely; the vitriol flower is difficult to become big. However, the work of reaction stage is that: the vitriol flowers condense to large vitriol flower pellets with size $0.6\sim 1.0\text{mm}$ in the slow water current of the reaction basin after certain time in order to sink fast in the sedimentation basin. There are many types of reaction basins. The commonly used are the clapboard reaction basin of advection type and vertical mobility type, the reaction basin of whirlpool type, the machinery reaction basin and the table-flap reaction basin.

(2) Sedimentation: the colloid impurity condenses to bigger vitriol flower granules in the water after adding the coagulant into the original water passing through mix reaction, the next is that they will be removed in the sedimentation basin. At present, the commonly used sedimentation pools are the sedimentation basin of advection type, the sedimentation basin of radial flow type, the sedimentation basin of sloping plate or of sloping

tube. Among those, the sloping plate and sloping tube sedimentation basin are more widely used.

(3) Filtration, one part of particles whose size are big or easily to be sank have been removed after the coagulation and the sedimentation of the original water, and turbidity of the water reduces by 100~150 approximately. But in order to enhance the water quality further, and make the turbidity to fulfill the drinking water standard, the method of filtration is also needed to get rid of the tiny impurity particle and parts of bacteria. The most commonly used filtration basins are the ordinary quick filtration basin, the siphon filtration basin, the non-valve filtration basin, the motion flushing cover filtration basin, and the pressure filtration basin. The filtration basin can clarify the water mainly depends on the filtration materials including quartz sand and anthracite grain. In addition, the plastic bead, the ceramsite, the magnetite grain are also used.

(4) Disinfection, disinfection is essential to prevent the spread of disease through drinking water in the treatment of domestic drinking water. Disinfection aims to eliminate the pathogenic effect of pathogenic microorganisms. Pathogenic organisms include bacteria, viruses and so on. The disinfecting methods of water may be divided into the physical disinfection and the chemical disinfection. The physical method includes the heating method, the ultraviolet radiation method, and the ultrasonic wave method. The chemistry method includes the chlorining method (or adding bleaching powder), the ozone method, the heavy metal ion method, or other oxidant method and so on. At present, the chlorining method is the most common one. The water after disinfecting can be transported into the pipe network for the users.

In addition, softening processing or desalination processing and so on are often needed according to the needs of the industrial use of water.

The technical process of purification

According to the hygienic standard requirement of domestic drinking water, the choice of the technical process of purification mainly depends on water quality characteristic of water source. Therefore, we have to conduct full investigation of the water quality of water source, then we can decide reasonable purification method and the technical process.

When the mine water wants to be used as the water source of domestic drinking water, we generally use the purification process shown in Figure. 1. Firstly, we add the coagulant in the water, and

make them mixed rapidly and fully after the agitation of water pump impeller. Then they grow gradually into the flocculent deposit material (flocculating constituent or vitriol flower) in the reaction basin. After getting rid of the vitriol flower in the sedimentation basin and in the filtration basin, we add the chlorine into the clear water to disinfect, then the water will be supplied to the users.

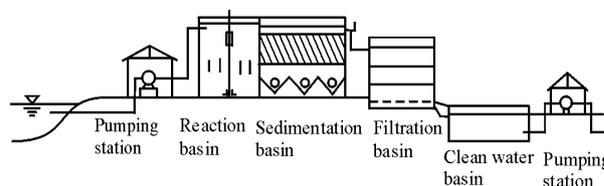


Fig. 1. Schematic diagram showing the purification.

If the mine water turbidity is low (frequently below 100o), the water added medicament can be directly filtered without coagulating sedimentation, this can omit the reaction basin and the sedimentation basin. After adding the chlorine disinfecting of the filtrated water, the pumping station transports the water into the pipe network. Its process is shown in Figure. 2.

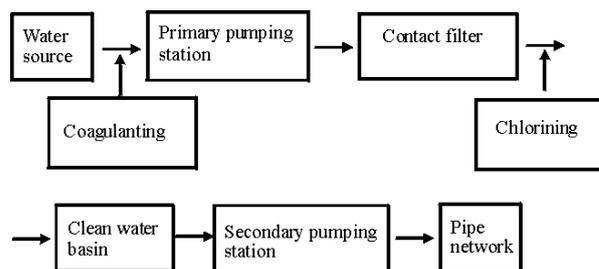


Fig. 2. Purification process of low-turbidity water.

For high turbidity water, in order to save the coagulant and achieve the anticipated effect, we can use the natural sedimentation method before the coagulating sedimentation. A lot of massive silts can be precipitated from the original water before future purification. The process of purification is shown in Figure. 3. According to practical experience, the common process of purification at present is:

coagulation→sedimentation→filtration→disinfect on.

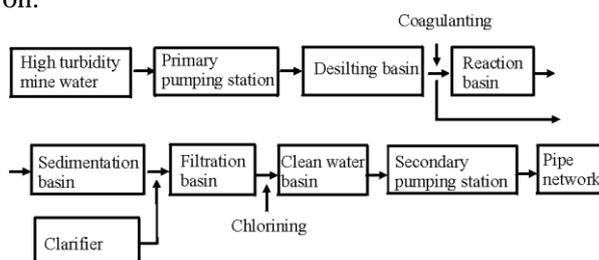


Fig. 3. Purification process of high-turbidity water.

APPLICATIONS

Pingdingshan Coal Group Company in Henan has accumulated rich experience in the term of water purification processing, and created a path of converting mine water into resource. Since 1977, Pingdingshan Coal Group Company built the first mine water purification factory, the company has built 16 mine water purification factories so far. Over 38 000 000 m³ mine water after purification reached “sanitary standard for drinking water” every year. The water becomes the main water source of production and living water, it also made the farmers nearby use the tap water. The main structures of water processing company include sand basin, reaction basin, sedimentation basin, filtration basin, and clean water basin. The water after processing can be directly supplied to the users. It has solved the water shortage problem of the mine area. The water is black before disposed, the suspended content is more than 200mg/L, and the turbidity is 150~300 degree. The sensory characteristic target of the purified mine water after disposed is good, the suspended solids may be eliminated, the water turbidity can achieve 3.50~6.50, the bacterium indexes of water fulfill the “sanitary standard for drinking water”.

Wannian Coal Mine of Fengfeng Group Limited Company, the purification plant was designed by Wuhan Design Institute of Coal Mine, and the invested over 0.7 million yuan. The designed purification mine water is 5200 m³/d, and it was operated in 1985. The main buildings are sewage regulating basin, pumping station, response basin, filtration basin, disinfection room, water storage, clean water basin and so on. The main technological processes are shown in Figure. 4. The water after purification passed the analysis of the water quality, and conforms to “sanitary standard for drinking water”. The cost of processing water is 1.5 yuan per ton at present.

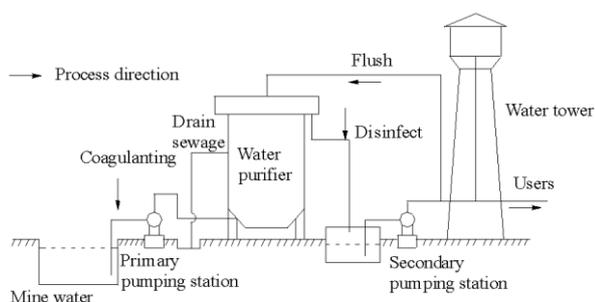


Fig. 4. Purification process of the mine water in Wannian Coal Mine

Tangshan Coal Mine subordinated to Kairuan Group Company invested 12.4 million yuan to construct mine water purification factory in 1992.

The designed capacity of water purification is 15000 m³/d. After purification, the turbidity of the mine water is less than 1 degree, conforming to “sanitary standard for drinking water”. By the end of 2004, the mine water processed had accumulate to 5860×10⁴ m³. While reducing the costs of drainage sewage and pumping groundwater resource for the enterprise, it also created tremendous social, economic and environmental benefits. Currently, the number of water-using households is over 10000. Taking the benefit of 2004 as example, the total annual production of purified water is 366.9×10⁴ m³, the cost is 1.32 yuan per ton, however, the cost of pumping underground water is 2.12 yuan per ton, thus, we can save 2.9352 million yuan.

For small type of supplying water (≤60m³/h), the integrative water purifier may be directly used. Now, a lot of coal mines in China use the integrative water purifiers to purify the mine water containing suspended solids. It was a small water purification device developed in 1980s in our country focused with reaction, sedimentation and filtration. It has advantages of small volume, small land occupation and convenient transportation. The integrative water purifier can be divided into the hydro-cycle type and the coagulation-sedimentation type. Now the coal mine enterprises mainly use the purifier of hydro-cycle type to purify the mine water. The processes of using the water purifier to purify the mine water are shown in Figure. 5.

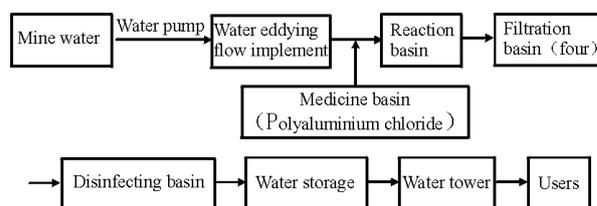


Fig. 5. Purification process of the integrative water purifier.

CONCLUSION

China is a large country of coal production. In the coal mining process, we must discharge massive mine water to ensure the production security. The great massive mine drainage has caused not only the waste of groundwater resource, but also environmental pollution. On the other hand, the industrial and agricultural water in the mining areas is extremely scarce, domestic water in many mining areas is also extremely shortage. Strengthening the research on the new techniques and utilization of mine water purification can mitigate the water crisis, promote

the economical sustainable development, and protect ecological environment.

From the mine water features, majority of mine drainage water belongs to the mine water containing the suspended solids. The mine water needs to be necessarily purified before used. Purification mainly eliminated the suspended and colloid impurity. The common methods of handle the mine water for drinking are coagulation, sedimentation, filtering and disinfection. At present, many coal mines use the small type water purification device (integrative water purifier), which contains reaction, sedimentation and filtration to process the mine water, obtaining the good effect. The water purification plants of Pingdingshan Coal Group Company, Wannian Coal Mine of Fengfeng Group Limited Company and Tangshan Coal Mine of Kailuan Group Company, not only solved the problem of the mine production and domestic water, but also have reduced the costs of drainage sewage and pumping groundwater resource for enterprises, they also created

tremendous social, economic and environmental benefits.

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