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Study and Utilization of Mine Water Purification

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Abstract: China is a big country of coal production, in the coal mining process, the great 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, the majority of mine drainage water belonging to the mine water containing suspended, the mine water needs to do the necessary purification then can be used. What the purification mainly eliminates is the suspended. In this paper, the method of purification and the technological process about mine water are discussed. The main methods of handling are coagulation, sedimentation, filtration and disinfection. According to different characteristics of water quality, different ways of handling and technological processes have to be chosen. Finally, the purification and utilization of mine water are shown through practical examples, Pingdingshan Coal Group Company, Wannian Coal Mine of Fengfeng Group Limited Company and Tangshan Coal Mine of Kailuan Group Company, to have obvious social, economic and environmental benefits.

Keywords: Mine water, purification, turbidity

I. INTRODUCTION

China is a big country of coal yield, raw coal production in 1990 amounted to 10.79×108 t, in 2005 reached 21.1×108 t. It has been ranking the first in the world for many years [1]. Coal is the main energy source in our nation, accounting for over 70% of our one-time energy consumption. Chinese coal mainly takes underground mining, accounting for about 97% of the overall coal production. As coal bed generally buried below the underground aquifers, in the coal mining process, to ensure the mine safety, people must discharge the massive water effused from mine pits. According to incomplete statistics, the drainage of whole national coal mine approximately is 22×108 t per year, and the average drainage is about 4m3 when mining 1t coal, but the utilization factor 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 make the contradictions between drainage and supply water more outstanding, and exacerbated water crisis. On the coal industry, nationwide, 70% of the area faces to water shortage, 40% is serious water shortage, and much mining area life supply water is very tense [5]. With the economic and social development and the exploitation of coal resource, the contradictions between mine drainage and industrial, agricultural, life supply water also will become more and more prominent. Strengthening the new technique research of mine water purification and using can mitigate the water crisis, promote the economical continual development and protect ecological environment and so on, it is of great significance.

II. MINE WATER QUALITY FEATURES

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

Containing suspended mine water is the mine water in which the content of suspended solid (commonly expressed by SS) not dissolved is much high. The general content of suspended is 100~500 mg/L, some is over 1000 mg/L. Therefore, the turbidity of mine water is higher, the general turbidity is about 100~300 degree. The suspended objects in the mine water are mainly from a great deal of coal fine, rock dust as exploitation activity generate into the mine water. Therefore, the mine water color becomes dark, sensory situation is very bad.

Under normal circumstances, mine water generally stays for a period of time in the mine water storage

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(generally 4~8 h), so larger size pieces of coal granule, rock granule and other solid particles can be naturally deposited in the bottom of the water storage as their gravity. Then, the drainage equipment pumps the mine water in the water storage to the ground. So the size of the suspended objects pumped to the ground is generally smaller, the majority particle diameters are below 50 μm, moreover, the density of suspended particles are also smaller, the average density is 1.2~1.3 g/cm^3, so its subsidence speed is very slow.

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

Mine water, specially the karst deposit which is filled with water, the original water is generally high quality groundwater, and the type of water quality is HCO_3 or HCO_3-SO_4. The degree of mineralization of water is generally smaller than 1 g/L. The total hardness is smaller than 25 German degree. As a result of the exploitation, after the wall rock groundwater flowing into the mine system with the massive mine dusts, the dusts and the rock debris pellet in different size which is formed after the adjoining rock layers destroying. They make the water quality bad; specially make the suspended content rise. And they make the reproduction of the bacterium and the mildew increase quickly. The water is turbid and the feeling and seeing state is not good. Therefore in order to be used, mine water needs to be carried on essential purification [7].

III. The purification About Mine Water

A. The Method of Purification

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

The principal characteristic about suspended is that it often presents in suspended state in dynamic water. But it may be separated in the still water, light matter will float up, and heavy one will sink down. The principal characteristic about colloid grain is that it is quite stable in the water, it will not naturally subside in still state by long time even several years. When light illuminates, it is scattered and causes the water to assume the feculent phenomenon. According to the characteristics of the suspended and the colloid, to the life drinking water, the main methods of the purification commonly used are coagulation, sedimentation, filtering and disinfection.

(1) Coagulation, it is the extremely important aspect in the water purification technology. In the process of dealing the turbid water to be the clear water, it needs to add the coagulant. The principles that we select the coagulant are that it 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; the source of goods is sufficient. Simultaneously we should select the coagulant with the water quality characteristic and the water temperature of the water source and so on. The commonly used coagulant may be divided into two kinds. One kind is the aluminum salt coagulant, another is the molysite coagulant. They are such as aluminum sulfate ($A1_2SO_4 \cdot 18H_2O$), iron trichloride ($FeC1_3\ 6H_2O$), ferrous sulfate ($FeSO_4\ 7H_2O$), polymerization aluminum chloride, and organic high molecular polymer flocculants. Among those, aluminum sulfate is the most widespread coagulant to be used at present, and the next 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 possible short time and enables the whole colloid impurity in the water to react with the medicament. At present the majority water factories use two methods of the water pump mix and the pipeline mix. That the water and the medicament pass through the fast mix appears the tiny vitriol flower. In order to sink rapidly, it must be made agglomerated into certain sizes (0.6~1.0 mm), and close-grained, not frangibility. But in the coagulation stage, the current of water turbulent motion intensely, the vitriol flower is difficult to continue to become big. However the reaction stage is that: in the slow current of water in the reaction basin, passing through certain time, it causes the tiny vitriol flowers to condense to be the vitriol flower pellets in 0.6~1.0mm size in order to sink fast in the sedimentation basin. There are many types of reaction basins. The following several kinds are commonly used, such as 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, after adding the coagulant into the original water, passing through mix reaction, in the water the colloid impurity condenses to be the bigger vitriol flower granules, the next is that they will be removed in the sedimentation basin. At present, the following several kinds of sedimentation pools are commonly used, such as 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 widely used.

(3) Filtration, after the coagulation and the sedimentation of the original water, one part of the particle whose size is big or easily to be sank has been removed, and turbidity of the water reduces by 10^{o}~15^{o} approximately. But to enhance the water quality further, and cause the turbidity to conform to the drinking water standard, it is also needed to use the method of filtration to get rid of the tiny impurity particle, including parts of bacteria. While filtration, we most commonly use the following several kinds of filtration basin, such as 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 make the water clarify mainly depending on the filtration materials, which we commonly used, including quartz sand and anthracite grain. In addition, the plastic bead, the ceramsite, the magnetite grain and so on also are used

(4) Disinfection, to prevent the spread of disease through drinking water, in the treatment of domestic drinking water, disinfection is essential. Disinfection are 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 most common. The water after disinfecting can be transported into the pipe network for the users.

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

B. 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 the full investigation to the water quality of water source. Then we can decide the reasonable purification method and the technical process.

When the mine water wants to be used to the water source of domestic drinking water, generally we use the purification process shown in Figure 1. Firstly we add the coagulant in the water through the agitation of water pump impeller to mix rapidly and fully. Then the water arrives in the reaction basin to grow gradually into the flocculent deposit material (flocculating constituent or vitriol flower). 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.

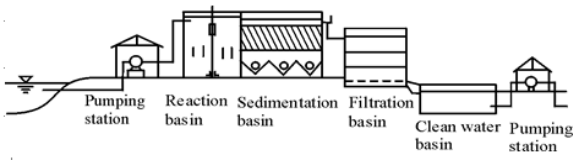

Figure 1. Schematic diagram showing the purification.

If the mine water turbidity is low (frequently below 100^{o}C), the water added medicament can be directly filtered but not the coagulating sedimentation, omitting 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.

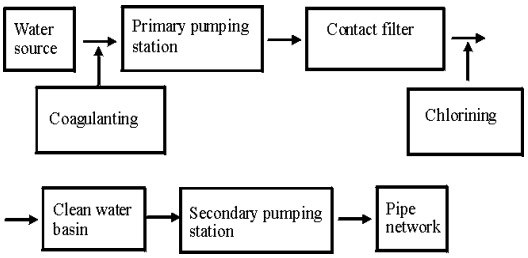

Figure 2. Purification process of low-turbidity water.

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 part of the massive silt is precipitated from the original water, then, the next is of purification. The process of purification is shown in Figure 3. According to the practical experience, at present the common process of purification is

coagulation→sedimentation→filtration→disinfection.

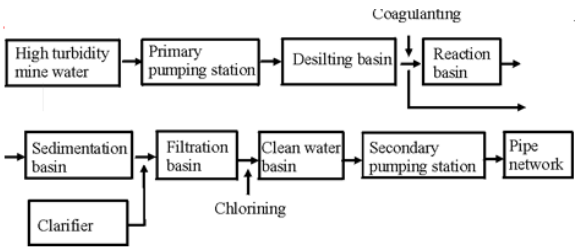

Figure 3. Purification process of high-turbidity water.

IV. 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. In 1977 Pingdingshan Coal Group Company built the first mine water purification plant, so far, the company has built 16 mine water purification plants. Over 38 million m^3 of mine water through purification reached "sanitary standard for drinking water" every year. The water becomes the main water source of production and living water, while it also made the farmers nearby use the tap water. The main structures include sand basin, reaction basin, sedimentation basin, filtration basin, and clean water basin. The water by processing can be directly supplied to the users. It has solved the tense problem of water shortage of the mine. Before the mine water is disposed, it is black, the suspended content is more than 200 mg/L, and the turbidity is 150~300 degree. After disposed, the sensory characteristic target of the purified mine water is good, the suspended may be eliminated, the water turbidity can achieve 3.5°~6.5°, the bacterium index of the water conforms to "sanitary standard for drinking water".

Wannian Coal Mine of Fengfeng Group Limited Company, the purification plant designed by Wuhan Design Institute of Coal Mine, invested over 0.7 million yuan. The design of purification mine water is 5200 m^3/d, and it 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 Fig 4. The water after purification, through the analysis of the water quality, conforms to "sanitary standard for drinking water", mainly for the production and life of the mine. The cost of processing one ton of water is 1.5 yuan at present.

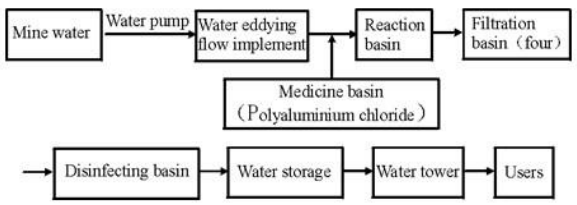

Figure 4. Purification process of the mine water in Wannian Coal Mine.

Tangshan Coal Mine subordinated in Kairuan Group Company invested 12.4 million yuan to construct mine water purification plant that went into production in 1992. The design capacity of water purification is 15000 m^3/d. After the purification of the mine water, turbidity is less than 1 degree, conforming to "sanitary standard for drinking water". By the end of 2004, the mine water processed had accumulatively reached 5860×10^4 m^3. While reducing the costs of drainage sewage and pumping groundwater resource for the enterprise, also it created tremendous social, economic and environmental benefits. Currently water-using households has reached over 10000. Benefit analysis take 2004 for example, the total annual production of purified water is 366.9×10^4 m^3, 1 ton water cost is 1.32 yuan, but 1 ton water cost of pumping underground water is 2.12 yuan, compared with the both we can save 2.9352 million yuan.

About a small type of supplying water (≤60 m^3/h) may directly use the integrative water purifier. Now, throughout the country a lot of coal mines use the integrative water purifier to purify the mine water containing suspended .It was a small water purification device developed in 1980s in our country with reaction, sedimentation and filtration. It has the advantages of small volume and little land occupation and convenient transportation. The integrative water purifier can be divided into the hydro-cycle type and coagulation-sedimentation type of the integrative water purifier. 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.

V. CONCLUSIONS

China is a big 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, in the mining area the industrial and agricultural water is extremely scarce, domestic water in many mining areas is extremely of shortage. Strengthening the research on the new techniques of mine water purification and using can mitigate the water crisis, promote the economical sustainable development, and protect ecological environment and so on, it is of great significance.

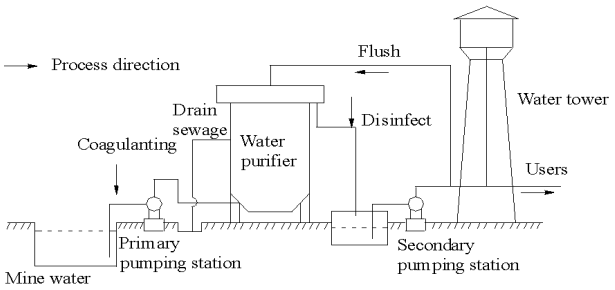

Figure 5. Purification process of the integrative water purifier.

From the mine water features, the majority of mine drainage water belongs to the mine water containing

the suspended objects. The mine water needs to necessarily purify can be used. Purification mainly eliminated the suspended and colloid impurity. The common methods of handling 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. Pingdingshan Coal Group Company, Wannian Coal Mine of Fengfeng Group Limited Company and Tangshan Coal Mine of Kailuan Group Company constructed the water purification plants. They have not only solved the tense problem of the mine production and domestic water, but also have reduced the costs of drainage sewage and pumping groundwater resource for enterprises, at the same time, have created tremendous social, economic and environmental benefit.

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