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Study on mechanisms of treating mine wastewater by goaf and the methods of recycling mine wastewater in Jining No.2 coal mine

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Abstract

Suspended solids are major pollutants of mine wastewater that can be recycled by flocculating, settling, and filtering for domestic and industrial use. For a long time, only a few collieries have adopted traditional technology to dispose of and recycle mine wastewater because of high cost. Most of mine wastewater is directly discharged, which not only contaminates the environment but also wastes precious water resource. So it is of great importance to explore new efficient treatment methods with low cost. Goaf which is full of broken stones has many interstices with different sizes suitable for filtering and purifying wastewater. Through model goaf, this paper mainly deals with the methods and mechanisms of wastewater treatment by goaf under coal mines. According to the characteristics of different goaf of Jining No.2 mine, we choose the best disposal scheme. Treating wastewater by goaf can utilize the mine wastewater effectively and economically.

Keywords: mine wastewater; recycling; suspended solids; filtering and purification; Goaf

1. Current state of drainage and treatment of mine wastewater in China's coal mines

During the process of coal-mining, water inside the aquifer enters the mining space to come into being mine wastewater. According to an incomplete statistics, about 2.2 billion tons of mine wastewater is discharged annually with a low reusing rate of less than 20%. There are some 5000 large-type drainages consuming power 3 billion kWh per year. In some collieries the drainage cost of mine wastewater amounts to 5 RMB for each ton of coal, exclusive of water resource fee and fine for wastewater emission. The mine wastewater that is not disposed is bound to pollute ground water bodies and farmlands. In addition, it also threatens the drinking water as well as aquatic plants and animals. On one hand, water resource is seriously wasted, on the other hand, fresh water is deficient. About 70% collieries all over the country are lacking in fresh water, 40% collieries are seriously lacking in fresh water, especially in North China[1,2]. In recent years, with the increase of coal output and the development of economy of mine areas, especially the construction of power plants and coke plants in mining areas, the water for production and living has become more and more deficient. So disposing and reusing mine wastewater not only involve

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environment protection and saving water resource but also are essential to the sustainable development of economy in many mine areas[3,4].

In China's collieries, mine wastewater mainly comprises suspended solids with coal dust and rock dust, and soluble inorganic matter, containing little organic matter and toxic matter. Most of mine wastewater is neutral and is good in water quality[5,6], the value of mine wastewater is generally ignored because of the traditional coal-mining way and recognition. In this case, low-cost processes and methods are badly needed for mine wastewater treatment.[7].

2. Traditional mine wastewater treatment and existing problems

At present, the mine wastewater of Jining colliery No.2 is directly discharged from the central underground wastewater store to the ground wastewater treatment systems, where traditional processes such as flocculating, settling, filtering and so on are adapted to remove suspended solids. The rough sketch of process is shown in Fig.1.

According to Fig.1, the disposing process of mine wastewater is as follows: at first the mine wastewater of different places under the colliery converges to the central underground wastewater store, and then goes to the buffer tank where wastewater quality is regulated at a balanced state and part of the particles settle by gravity. After pumping the mine wastewater from the buffer tank to the reacting tank, add coagulating reagent to promote flocculation in reacting tank. Small suspended solids inside the mine wastewater react with coagulating reagent to form large-sized suspended solids with good characteristics of settlement. Let the mine wastewater containing large-sized suspended solids settle in the settling tank and discharge the precipitate to the condensing tank. After condensing the precipitate, pump it to the drying place to dry naturally for other use. The effluent from the settling tank flows through the double-decked filtering materials to the clear water tank. The water inside the clear tank must be disinfected by means of contact oxidation before transporting it to the water supply pipelines for the use of production (washing coal) and living (afforesting, bathing).

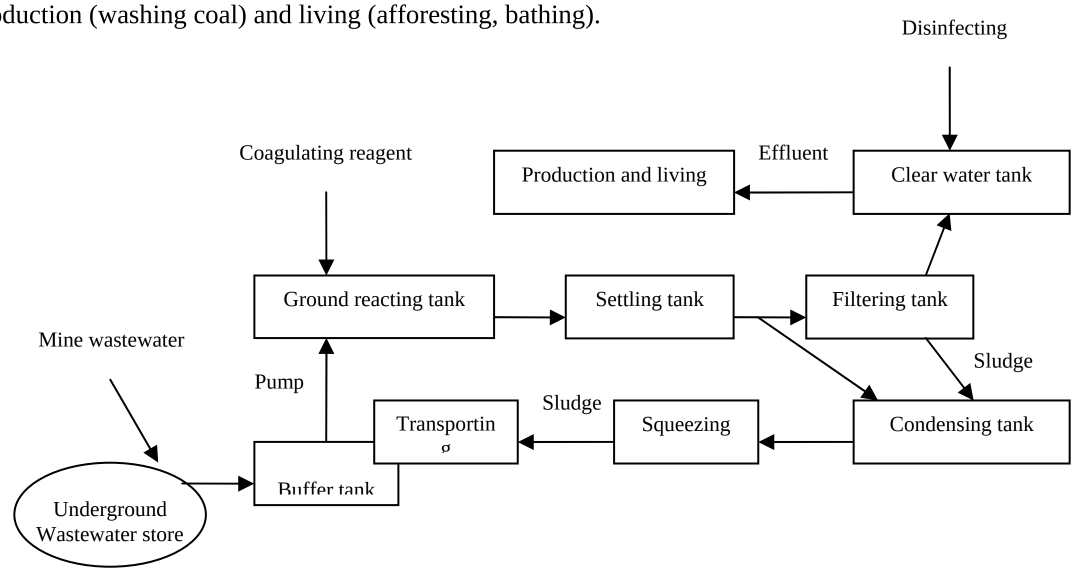

Fig. 1. Traditional mine wastewater treatment technology in Jining Colliery No.2

There exist some practical problems in adopting traditional processes to dispose of mine wastewater. They are mainly as follows:

1) Heavy initial investment and high disposing expenses. Money for electricity has to be spent in draining wastewater from the central underground wastewater store to the ground. Coagulating reagent is expensive and in great demand.

2) Present wastewater treatment capacity ($300m^3/h$, maximum is $360m^3/h$) can not meet the demands after 2005.

3) The problem of silt in the mine wastewater store of working area remains unsolvable, which increases the run cost and affects the production directly.

4) Traditional processes are a big waste of fresh water for removing dust under ~~collieries~~mine. If mine wastewater can be purified under the ground for ~~use of~~ dust removal,a large sum of money for power will be saved for it is unnecessary to draw mine wastewater to the ground.

3. Analysis on effect and mechanisms of disposing mine wastewater by goaf

After the coal layers are excavated, the space left is called goaf. Because of the change of pressure after excavation, the rock on the coal layers collapses to fill the goaf with many broken stones.

These broken stones are different in size, forming many interstices suitable for infiltrating and filtering mine wastewater.

3.1. The difference between indoor model goaf and traditional artificial filtering tank

As is known to all, as filtering materials, the smaller the broken stones are, the smaller the interstices are, the better the filtering capacity is, and the smaller the sizes of the suspended solids can be filtered are. But the goaf, after all, is different from artificial filtering tanks. The sizes of broken stones collapsed are uneven, impossible to be the same with the ones of artificial filtering tank. So stones are mixed together in the model and are far bigger than stones in traditional artificial filtering tank [8].

3.2. Experiment process and result analysis

By filtering 4 samples of mine wastewater with different turbidity values in the indoor model goaf, a common law is found. As Fig. 3, at zero moment, both of the effluents are low in turbid degree, which means that they are not mine wastewater being tested but wastewater remained from the last experiment. At first the turbidity value of the effluent dropped sharply and then smoothed down gradually. The longer the time is, the narrower the decrease margin is. The total removal rates of the suspended solids are all above 94%. In terms of the preceding phenomena, the main purifying mechanism can be concluded as absorption, interception, and settlement, which are that 1) the characteristics of absorption is that at first suspended solids can be effectively absorbed, with the lapse of time, the effect declines, which is in accordance with the experimental phenomena; 2) interception action makes interstices smaller and smaller, but purifying capacity is improved on the contrary as time goes by. But experimental result showed that the longer the filtering time, the slower removal rate of suspended solids, the worse the purifying effect, which demonstrated interception action did not play a major role; and 3) settlement action is obvious in removing big suspended solids. As time goes on, small suspended solids account for a large percentage inside mine wastewater, uneasy to be removed, the settling capacity becomes weak. Just because of above several mechanisms, purifying effect takes on different features at different stages[8].

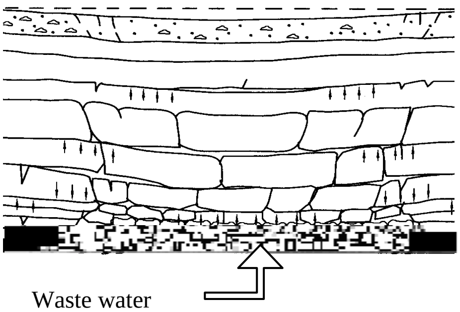

Fig. 2. Treating wastewater by Goaf

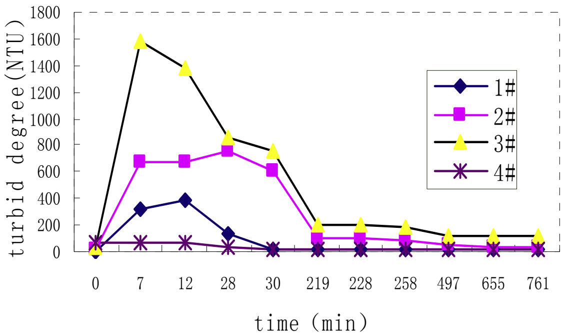

Fig. 3. Diffrent samples about turbid degree-time

In fact, compared with the model goaf, the real goaf has its own characteristics. 1) In the real goaf, the sizes of rocks are more uneven than those in the model goaf, and there are a lot of smaller broken stones. As a result, many smaller interstices came into being, which are conductive to interception and absorption actions. 2) In the model goaf, the filtering process lasts only over ten hours. But actually it takes about 2 months for the mine wastewater to flow out of the real goaf, much longer than the flow time in the model goaf. 3) The practical space of the real goaf is far bigger than that of the model goaf, so the purifying effect will be much better, the effluent will also be lucider, which can be proved from the permeated clean mine wastewater in the real goaf.

4. Schemes for choosing goafs

In Jining Colliery, there are now 5 goafs to choose for disposing mine wastewater. Each goaf is considered as an optional scheme. The analysis is as follows:

Scheme 1:

Strong points:the goaf is ready for disposing mine wastewater and investment is low.

Weak points:

1). 20m-long coal pillar has to be set in the goaf from Coal face 33D02 to Coal face 33D01.

2). The available of goaf is small and purifying capacity is comparatively low.

3). 50m-long tunnel has to be built in the goaf from the southern-flanked transport tunnel to Coal face 33D01.

Scheme 2:

Strong points: the goaf is available as soon as the Coal face 33D05 is excavated up. The investment is also low.

Weak points: the available area of goaf is small and purifying capacity is low.

Compared with Scheme 1, Scheme 2 is the better.

Scheme 3: this is similar to Scheme 2.

Scheme 4:

Strong points: the area of goaf is big enough to dispose plenty of mine wastewater with good purifying effect. Moreover, the service period is long.

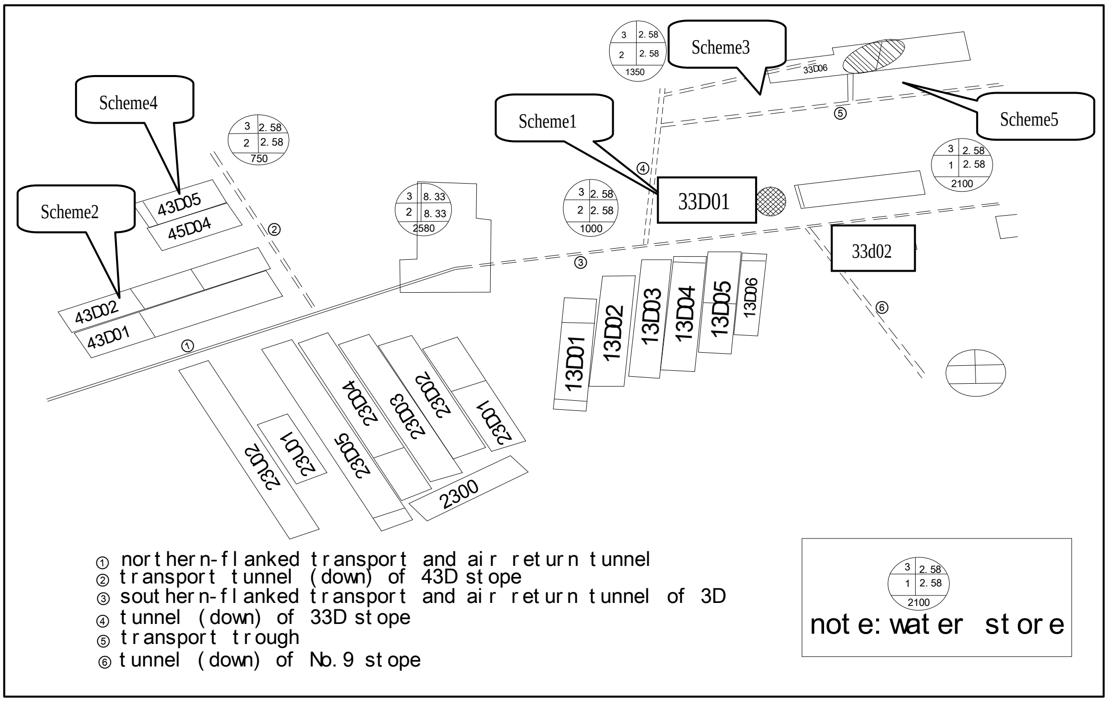

Fig. 4. Rough sketch of 5 Goafs distribution

Weak points:

1) The goaf is not available until Coal face 43D03 and Coal face 43D06 are excavated up.

2) The use of gGoaf causes inconvenience for flood prevention under the mine.

3) Heavy investment.

Preliminary work:

1) Build a tank for clear water.

2) Consolidate the hermetical walls in case of being broken through.

3) 50m-long tunnel has to be built in the goaf from No.6 liaison tunnel to Coal face 43D01.

In the long run, Scheme 4 is better than the preceding three schemes.

Scheme 5: Scheme 5 is similar with Scheme 4 in strong points and mechanisms. But Scheme 5 need not preliminary work. The investment of Scheme 5 is also less than that of Scheme 4. The goaf is only available till all the coal faces are finished. In contrast, Scheme 5 is the better than Scheme 4.

As already explained, Scheme 5 is the best from the perspective of the natural facilities utilization, purifying effect, purifying capacity, economic feasibility and service period. The distribution of five goafis shown as figure 4.

5. Conclusions and suggestions

1) The purifying effect of model goaf is very remarkable. The removal rates of the suspended solids are all over 94%.

2) The removal speed is high at the start, showing a trend of gradual decrease.

3) The main mechanisms of mine wastewater treatment by goaf can be concluded as follows: absorption, interception and settlement.

4) Compared with model goaf, the real goaf has its own characteristics. In the goaf, the sizes of rocks are more uneven, the flow speed is far smaller, the practical capacity of goaf is far bigger, so the real purifying effect will be much better.

5) Scheme 5 is the best from the perspective of the natural facilities utilization, purifying effect, purifying capacity, economic feasibility and service period.

The next step should be prospecting the hydrogeological and geological condition of goafs The interstice degree, sizes of particles, purifying capacity, disposing volume and service period of goafs should be clear. In addition, the economical indices of pipeline in every goaf should be contrasted.

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