

# Study on a Coal Washing Wastewater Treatment Process and Its Application with Carbide Slag and Polyacrylamide

Yafeng Li, Xiaoning Zhang

*Environmental and municipal school of Shenyang Jianzhu University, Shenyang, China, 110168*

*Email: yafengli88@sina.com*

**Abstract:** A new technology of high concentration coal washing wastewater treatment was developed in order to solve the difficulties in this field. Character of high concentration coal washing wastewater was analyzed and experiment was conducted and a technology of coagulant and sediment with carbide slag and PAM (polyacrylamide) for coal washing wastewater treatment was developed. Main technical parameters were identified by experiments. This technology performed well in the treating of high concentration coal washing wastewater and has been applied in the engineering. The running effect showed that the coal washing wastewater treatment system adopting this technology had a stable treating effect and high supernatant liquid separation rate. The quality of effluent can meet all the requirements of discharge and reuse standards.

**Keywords:** Coal washing wastewater; Coagulation and sedimentation; Treatment; Reuse

## Introduction

High concentration coal washing wastewater is produced during the washing of coal with short geologic time and high contents of ash and impurities. The suspended substance concentration in this kind of wastewater is high and there're strong negative charges on the surfaces of the particles, so a stable colloid system is formed and it's so hard to sediment that the water is difficult to treat <sup>[1]</sup>. This problem has been studied since the 1960s in China, but no preferable solution has been recommended <sup>[2]</sup>. The character of this kind of water was studied and a coal washing wastewater treatment technology was developed in this study, in which carbide slag (or lime) and PAM were used to coagulate and sediment. This tech was applied in some collieries of Tiefa Mining Bureau and the effect performed preferable. This tech passed the technical evaluation organized by Shenyang Science and Technology Bureau in 2003. The research result was considered to have come up to the international advanced level and won the Second Place

of Shenyang Prize for Progress in Science and Technology. In this paper, the high concentration coal washing wastewater treatment technology and its application are introduced, sampled by the conducting in Xiaoming Colliery of Tiefa Mining Bureau.

## 1 Experimental study on the high concentration coal washing wastewater treatment

### 1.1 Quantity and quality of coal washing wastewater from Xiaoming Colliery

The coal washing factory in Tiefa Mining Bureau was built and put into use in 1969. After three times of extending and improving, now its washing and separating capability is 1,400,000 t/a, with 400,000m<sup>3</sup> water slurry to discharge every year. The quality of the coal washing wastewater is presented in Table 1.

Table 1. Quality of the coal washing wastewater

SS(mg/L)	COD(mg/L)	pH	Zeta potential (-V)	Sludge ratio residence (m/kg×10 <sup>13</sup> )	Content of particles smaller than 75μm(%)
70000~100000	25000~43000	8.14~8.46	0.0718~0.0742	3.47~3.63	62~65

As Table 1 shows, the coal washing wastewater was slightly alkaline, with high concentrations of suspended substance and COD; there're strong negative charges on the surfaces of the particles and the content of smaller particles which are hard to filter is high.

### 1.2 Static test to make the treating scheme

It is seen from the analysis above that the coal washing wastewater from Xiaoming Colliery is a colloid

disperse system and the colloidal particles have strong negative charges [3]. So coagulant is required in the treatment process of this coal washing wastewater to lower its zeta potential and destroy the colloid stability and then to gain effective separation. In addition, the study result showed that although COD of the coal washing wastewater was high, it was paralleled with SS, suggesting that the value of COD went up with SS. So it is proper to set SS as the main pollution agent.

### 1.2.1 Screening test of inorganic coagulant

According to the character of coal washing wastewater from Xiaoming Colliery, 7 kinds of inorganic reagent were chosen in the experiment. Each time, the sampling was 100mL, with SS of 90.3g/L. It was stirred for 60s, at the rate of 80r/min, and then settled for 48h. The result is detailed in Table 2.

Table 2. Tests of adding different coagulants

Index	Coagulant						
	FeCl <sub>3</sub>	CaCl <sub>2</sub>	Lime	Carbide slag	PFS	PAC	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>
Supernatant liquid separation rate (%)	3	14	28	26	2	3	1
Settling velocity (μ m/s)	—	1.4	3.4	3.3	—	—	—
SS in the supernatant liquid (mg/L)	—	54	58	63	—	—	—
COD in the supernatant liquid (mg/L)	—	26	28	31	—	—	—

Remark: The addition of each coagulant was 600mg/L.

The result showed that the treating effects of lime and carbide slag were preferable among 7 coagulants but the diameter of the formed particles was too small to settle down quickly and the condensate was hard to filter, so flocculant was required for deeper dewatering. Carbide slag was adopted in this project because its chemical composition is similar to lime but it could be collected in Xiaoming Colliery as a waste residue to save money.

### 1.2.2 Identification of treating scheme

The experiment results showed that the stability of coal washing wastewater can be destroyed by carbide slag, by settling the particles down. But the settling rate was too slow, so flocculant was required to promote the

settling and improve the sediment. Non-ionic PAM was selected according experiment and economic consideration. An orthogonal test was conducted since the addition quantity of carbide slag and PAM and the stirring time after the adding of them can all impact the settling velocity. In the orthogonal test, 100mL coal washing wastewater with SS of 90.3g/L was sampled each time, and carbide slag was added and stirred. Then PAM with a mass concentration of 0.1% was added and stirred again. The settling velocity was measured during the settling. The carbide slag was made into emulsion by stirring with 10mL water at a rate of 80r/min before it was used in the orthogonal test. The result is described in Table 3 and the variance analysis is shown in Table 4.

Table 3. Results of orthogonal test

No.	Addition of carbide slag (g)	Stirring time after the adding of carbide slag (s)	Addition of PAM (mL)	Stirring time after the adding of PAM (s)	Blank sample	Settling velocity (mm/s)
1	0.2	30	0.5	30	1	0.0421
2	0.2	60	1	60	2	0.1265
3	0.2	90	1.5	90	3	0.2583
4	0.2	120	2	120	4	0.2134
5	0.4	30	1	90	4	0.2067
6	0.4	60	0.5	120	3	0.1032
7	0.4	90	2	30	2	0.2846
8	0.4	120	1.5	60	1	0.2129
9	0.6	30	1.5	120	2	0.3081
10	0.6	60	2	90	1	0.4978
11	0.6	90	0.5	60	4	0.2034
12	0.6	120	1	30	3	0.1867
13	0.8	30	2	60	3	0.4068
14	0.8	60	1.5	30	4	0.2832
15	0.8	90	1	120	1	0.2145

16	0.8	120	0.5	90	2	0.1763
K1	0.6303	0.9637	0.525	0.7966	0.973	
K2	0.8074	1.0007	0.7244	0.9496	0.8955	
K3	1.171	0.9608	1.0625	1.1291	0.955	
K4	1.0858	0.7893	1.3855	0.8392	0.9067	

**Table 4. Variance analysis**

Source of variance	Sum of deviation square	Degree of freedom	Mean square	F	Critical value $\lambda_{0.05}$	Critical value $\lambda_{0.01}$	Significance
Addition of carbide slag	0.0375	3	0.0125	41.7	9.28	29.46	Very significant
Stirring time after the adding of carbide slag	0.0068	3	0.0023	7.7			Non significant
Addition of PAM	0.1007	3	0.0336	11.2			Very significant
Stirring time after the adding of PAM	0.0166	3	0.0055	18.3			Significant
Variance	0.0008	3	0.0003				
Sum	0.1624	15					

As the variance analysis shows, the main actor impacting the settling effects was the addition of PAM, the addition of carbide slag came later, then came the stirring time after the adding of PAM, but the stirring time after the adding of carbide slag performed much less impaction. The best composition condition was as follows: 0.6g carbide slag (in solution of 6%) was added into 100mL coal washing wastewater, then stirred for 60s, after that was the adding of 2.0mL PAM with a mass

concentration of 0.1% and then stirred for 90s.

### 1.2.3 Settling experiment at the best composition condition

The experiment was conducted at the best composition condition identified by the orthogonal text, with a sample with SS of 90,300mg/L. The result is described in Table 5.

**Table 5. Result of experiment at the best composition condition**

Real supernatant liquid separation rate (%)	Settling velocity (mm/s)	SS in supernatant liquid (mg/L)	COD in supernatant liquid (mg/L)	pH	Sludge ratio residence (m/kg $\times 10^{10}$ )
41	0.543	56	25	12.3	3.42

It was suggested in the experiment results that the adoption of the process to treat the coal washing wastewater with carbide slag and PAM was feasible. 40% of supernatant liquid was separated and the concentration of SS and COD in the supernatant liquid was much lower than the requirements of coal washing wastewater discharge standard and reuse standard. The filterability of the flocculating constituent was improved, which could promote the dewatering of the wastewater. However, since the pH of the supernatant liquid was relatively high, some industrial waste acid was required to add to lower the value of its pH to 8 or so. The volume of acid addition was: Supernatant liquid: Waste acid =1000: 1.

## 2 Engineering application and its conducting effect

### 2.1 The coal washing wastewater treatment

#### system and equipment of Xiaoming Colliery

Treatment scheme and design parameters were finalized according to the experimental study. The coal washing wastewater treatment project in Xiaoming Colliery was designed to improve according to its practical situation. The treatment process after the rebuilt is simplified in Figure 1 and the main equipment is listed in Table 6.

(1) The primary storage pool was used as balance tank, with a volume of 150m<sup>3</sup> and residence time of 2h.

(2) The hybrid reactions after the addition of agents were designed to conduct in pipeline reactors according to the ground situation of the site. On the basis of experiment and calculated results, the first pipeline reactor used after the adding of carbide slag was made with FD-200-2000, meaning a diameter of 200mm and length of 2m. The second pipeline reactor used after the adding of PAM was made with FD-250-2000, meaning a diameter of 250mm and length of 2m. The adoption of

pipeline reactors reduced the floor area and saved the investment.

(3) There used to be six large-scale sedimentation basins in Xiaoming Colliery. And in the project of rebuilding they were preserved temporarily and no new sedimentation basin was built, according to the requirement of the corporation. There was no sludge discharge equipment at the bottoms of these basins, so no

mechanical dewatering equipment was adopted in the treatment of the coal slurry. And slurry was dried by nature and then cleaned by manpower as the means of slurry disposal used to be.

(4) The treated water was discharged into the reservoir used for coal washing and no new treated water tank was built.

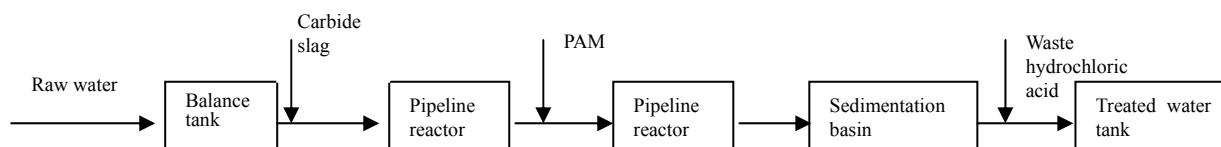


Figure 1. Treatment process

Table 6. List of main structure and equipment

No.	Name	Standard	Amount	Remark
1	Coal washing wastewater tank	150m <sup>3</sup>	1	Existed
2	Microcomputer flow meter	RML-160	1	
3	Sludge pump			Existed
4	Pipeline reactor	FD-200-2000	1	
5	Pipeline reactor	FD-250-2000	1	
6	Sedimentation basin	100000mm×30000mm×2000mm	6	Existed
7	Treated water tank		1	Axisted
8	Clear water pump	IS80-50-315		
9	Agitator	n =250r/min ,N=3.0kw	2	
10	Carbide slag adding tank	Φ3200mm,h4000mm	2	Antisepsis
11	Acid-resident pump	25F-S-16, N=1.5kw	1	
12	Slurry pump	2PN,N=11.0kw	2	
13	Agitator	n=130r/min,N=3.0kw	2	
14	PAM adding tank	Φ2400mm,h3000mm	2	Antisepsis
15	Flow meter	LZB-400-4000	2	
16	Clear water pump	IS50-32-125	2	
17	Acid storage tank	V=5m <sup>3</sup>		Antisepsis
18	Flow meter	LZB-F40-400	1	

## 2.2 Running effect

The treatment effect of Xiaoming Colliery coal washing wastewater treatment system has been stable since put into use in 1996. The quality of the treated water can meet all the requirements for discharge and all the treated water is used to wash coal as a way of reuse,

so a closed cycle of coal washing wastewater is formed. The treatment effect is detailed in Table 7. It has been proved that the coagulating and sediment process with carbide slag and PAM is feasible in the treating of wastewater produced in the washing of coal of not too long age.

Table 7. Treatment effects

Influent			effluent		
SS(mg/L)	COD(mg/L)	pH	SS(mg/L)	COD(mg/L)	pH