Influence of Water Quality on the Flue Gas Desulfurization in a 350MW Coal-fired Power Plant

Gaojun Liu 1, *, Xiangdong Cai2, Yue Guo1, Qing Li1

1North China Electric Power Research Institute Co.Ltd., Beijing, China
2Shenhua Guohua Sanhe Power Generation Co.Ltd., Langfang, China

*Corresponding author: liu.gao.jun@163.com

Abstract. With the national ultra-low emission requirements, a large number of wet flue gas desulfurization has been used in the normal operation of coal-fired power plants. After long-term operation, various impurities will be enriched in the slurry of the absorption tower, resulting in the reduction of desulfurization efficiency or foaming of the slurry of the absorption tower, which will seriously affect the operation of the unit. It is necessary to study the influence of water quality on the desulfurization reaction of lime slurry. When the incoming water is reclaimed water, process water and filtrate respectively, the desulfurization reaction is simulated on the laboratory bench to compare its influence on the desulfurization reaction characteristics. The results show that. (1) The effect of process water on the desulfurization process is as follows. The largest amount of foaming of the desulfurization slurry and the inhibition of gypsum crystallization reaction, but the characteristics of particle size distribution in the generated gypsum slurry are most conducive to the slurry dehydration and the gypsum crystal quality is good. (2) The function of the filtrate is to minimize the foaming amount of the desulfurized slurry and the effect on the gypsum crystallization reaction. The characteristics of particle size distribution in the generated gypsum slurry are favorable for the slurry dehydration. The gypsum crystal size is the largest, but a small number of crystal particles appear at the same time, which affects the slurry dehydration to a certain extent. (3) The role of reclaimed water lies between process water and slurry.

Keywords: desulfurization; water quality; recycled water; process water; filtrate.

1. Introduction

The energy structure of "rich coal, poor oil and little gas" [1] in China determines that coal accounts for more than half of the primary energy. Coal fired power plant is a large consumer of coal and one of the main emission sources of gaseous pollutants. In order to meet the national ultra-low emission requirements, limestone slurry is widely used in coal-fired power plants during normal operation. After long-term operation, various impurities will be enriched in the slurry of the absorption tower, resulting in the reduction of desulfurization efficiency or foaming of the slurry of the absorption tower [2-6], seriously affecting the operation of the unit [8-9]. As one of the input terminals of absorption tower slurry, the water quality will inevitably affect the quality of absorption tower slurry [10-12].
Therefore, it is necessary to study the influence of incoming water quality on desulfurization reaction of lime slurry.

2. Experiment

In order to investigate the influence of water quality on the flue gas desulfurization in a 350MW coal-fired power plant, the simulated reaction system for WFGD were designed and built in this paper, as shown in Figure 1.

![Figure 1. The simulation reaction system for the WFGD.](image)

1. Desulfurization reactor, 2. Constant temperature water bath system, 3. Air pump, 4. Conductivity meter, 5. NaHSO₃ aqueous solution, 6. Dosing pump.

3. Results and analysis

3.1. Influence on foaming of desulfurization reaction slurry

In this experiment, the foaming height of slurry in the reactor is used to quantitatively characterize the foaming situation, and the relationship between the water quality of desulfurization absorbent and the foaming height of slurry in the reactor is obtained, as shown in Figure 2.

![Fig.2 Relationship between water quality and foaming height](image)

It can be seen from Fig. 2 that the foaming amount caused by the preparation of absorbent with reclaimed water and filtrate is similar, and the foaming height corresponding to the deionized water in the laboratory is increased by 1.7 and 1.3 times respectively. The foaming height caused by process water is the highest. This is mainly due to the residual trace of water treatment agent in process water and the mixing of a small amount of organic impurities in the circulating treatment.
3.2. Influence on crystallization process of desulfurization slurry

The conductivity of water samples with different absorbents in the process of crystallization reaction was measured. The conductivity curve is shown in Figure 3. The characteristics of conductivity curve were analyzed, and then the crystallization induction time (T1), total crystallization time (T) and elongation ratio (K_T1, K_T) relative to the control group were obtained as shown in Table 1.

It can be seen from Fig. 3 and table 1 that the conductivity of the filtrate sample increases significantly compared with that of the deionized water sample, which is mainly due to the high concentration of ions in the filtrate. The slope of conductivity curve of filtrate sample is similar to that of deionized water, and the crystallization induction time and total time extension rate of filtrate sample are the smallest among the three groups of water samples, indicating that the filtrate has the least influence on the nucleation stage and crystal growth stage of crystallization reaction. The conductivity of process water sample is the lowest, and the crystallization induction time and total time extension ratio are the highest, which indicates that the inhibition effect on crystallization reaction is relatively obvious.

![Fig. 3 Conductivity curve of crystallization reaction of different water quality](image)

| numbe | water quality | K_T1 | K_T |
|-------|---------------|------|------|
| 1     | deionized     | 1    | 1    |
| 2     | reclaimed     | 1.94 | 1.51 |
| 3     | process water | 2.41 | 1.71 |
| 4     | filtrate      | 1.76 | 1.44 |

3.3. Influence on particle size distribution characteristics of desulfurization slurry

In this project, the gypsum slurry obtained from the desulfurization slurry test system is used to analyze the particle size distribution of the slurry. Several key indicators of particle size characteristics generally include D50, D10 and D90. D50 was also known as average particle size, means that the particles larger than it account for 50%, and the particles smaller than it also account for 50%; D10 means that the particles smaller than it account for 10% of the total number of particles; D90 means that the particles smaller than it account for 90% of the total number of particles; D10 and D90 are a pair of commonly used boundary particle sizes, which are used to represent the particle size distribution of the sample, that is, 80% of the particles are distributed between D10 and D90.

Figure 4 shows the particle size distribution of gypsum slurry for different water quality samples. It can be seen from the figure that compared with the deionized water samples, the position of the first peak of the gypsum particle size distribution curve of the three groups of water quality samples is basically unchanged, but the height decreases slightly; the position of the second peak moves to the right, and the range of the peak width becomes wider, and the peak height decreases. Comparing the
characteristics of gypsum particle size distribution curves of three groups of water samples, the process water sample has the highest peak and the narrowest range of peak width, which indicates that the process water makes the particle size distribution of gypsum slurry relatively more concentrated. The water and filtrate samples are close, the peak height is slightly lower, and the range of peak width is enlarged to the right.

![Particle size distribution of gypsum of different water quality](image)

Fig.4 Particle size distribution of gypsum of different water quality

It can be seen from table 2 that the three groups of water samples make the performance parameters of gypsum particle size increase, indicating that the gypsum particle size becomes larger. This feature is favorable for gypsum slurry dehydration. Among them, D50 of process water is the largest and d90-d10 is the smallest, which indicates that increasing the particle size of process water also increases the consistency of crystal size, so it can promote the subsequent dehydration process of gypsum slurry.

| water quality     | deionized water | process water | reclaimed water | filtrate |
|-------------------|-----------------|---------------|-----------------|---------|
| D10               | 16.36           | 25.34         | 18.37           | 24.62   |
| D50               | 86.39           | 121.7         | 101.44          | 119.42  |
| D90               | 194.91          | 265.91        | 283.63          | 337.77  |
| D90-D10           | 178.55          | 240.57        | 265.26          | 313.15  |
| average           | 94.09           | 134.41        | 126.84          | 153.68  |

3.4. Influence on gypsum crystal characteristics of desulfurization slurry

![The crystal morphology of gypsum at mass addition of magnesium ion](image)

Fig.5 The crystal morphology of gypsum at mass addition of magnesium ion
The morphology, size and distribution characteristics of desulfurization slurry crystals with different concentrations of magnesium ions were observed by 10xb-pc metallographic microscope to analyze the influence of magnesium ions through gypsum crystal characteristics on slurry dehydration.

Figure 5 shows the influence of water quality on gypsum crystal. The water quality types are a) deionized water; b) process water; c) reclaimed water; d) filtrate. Compared with the deionized water sample (Fig. a), in the other three groups of water samples (Fig. B, C, d), the crystal of calcium sulfate dihydrate becomes larger and the columnar crystal increases. The degree of crystal dispersion of process water and reclaimed water samples is high. These characteristics are beneficial to improve the quality of gypsum and promote the dehydration process of gypsum slurry. Among them, the crystal of filtrate sample is the largest, but there are some aggregation and debris particles in the distribution.

4. Conclusions
Based on the simulation system of wet flue gas desulfurization, the influence of water quality on slurry desulfurization reaction was studied

(1) The effect of process water on the desulfurization process is as follows: it makes the desulfurization slurry foam the most and inhibits the gypsum crystallization reaction, but the particle size distribution of gypsum slurry is the most conducive to slurry dehydration and the quality of gypsum crystal is good.

(2) The function of filtrate is as follows: the foaming amount of desulfurization slurry is the least, the influence on gypsum crystallization reaction is the least, the particle size distribution of gypsum slurry is favorable for slurry dehydration, the particle size of gypsum crystal is the largest, but a small amount of crystal fragments appear at the same time, which affects slurry dehydration to a certain extent.

(3) The role of reclaimed water lies between process water and slurry. The influence of water quality on the wet flue gas desulfurization system of coal-fired power plant is related to the desulfurization stage. In the actual operation process, the power plant personnel should grasp the main contradictions and flexibly deal with the water quality problems.

References
[1] ZHANG Cao. Countermeasures of coal enterprises under background of energy consumption structure adjustment in China [J]. Coal and Chemical Industry, 2017, 40(5): 133-136, 139.
[2] CHEN Yongxin. Analysis and solutions of absorber seriflux foaming overflow [J] Electric Power Science and Engineering, 2010, 26(10): 75-78.
[3] LI Xinghua, JIN Wanyuan, ZHANG Jinsong, et al. Influence factors of absorber slurry foaming in wet limestone-gypsum flue gas desulphurization systemst [J]. Thermal Power Generation, 2015(8).
[4] XING Changcheng. Analysis of the seriflux overflow in absorber area of FGD and its control measures [J]. Environmental Engineering, 2010, 28(1): 65-67.
[5] JSHEN Guoqing, YANG Yalong, AN Liansuo,et al. Study on separation performance of gypsum hydro-cyclone in wet limestone-gypsum FGD systems[J]. Journal of Chinese Society of Power Engineering, 2012, 32(8): 639-646.
[6] HANSEN, BRIAN B, KILL, ,et al. Foaming in Wet Flue Gas Desulfurization Plants: The Influence of Particles, Electrolytes, and Buffers[J]. Industrial & Engineering Chemistry Research, 47(9): 3239-3246.
[7] XIE Chunxia, ZOU Xiangqun. Water quality specification of reclaimed water used as process water of flue gas desulfurization system. [J]. Electric Power Environmental Protection, 2013, 29(2): 23-25.
[8] ZHENG Guanwen, DU Yancao, CAO Shun’an. Effect of recycled water on the reaction activity of limestone for desulfurization. [J]. Guangdong Chemical Industry, 2016, 43(15): 85-86.
[9] CHEN Xiaopin. Application of urban reclaimed water in Haibowan Power Plant [J]. Inner Mongolia Petrochemical Industry, 2010, 5: 28-29.
[10] QI Huizhong, CHEN Haitao, LI Guohua, et al. Brief introduction on profundity treatment to municipal reclaimed water in Xilinhaote thermal power plant. [J]. Inner Mongolia Electric Power, 2008, 26(3): 44-46.

[11] DENG Weimin, XUE Zhigang, XUE Zhiliang. Analysis of RO concentrated water as make-up water of desulfurization system [J]. District Heating, 2015 (02): 71-75.

[12] XU Hongjian, PAN Weilong, GUO Ruitang, et al. Investigation on characteristics of gypsum crystallization with metallic ions at different temperatures in wet limestone-gypsum desulfurization. [J]. Proceedings of the csee, 2010, 30(26): 29-34.