

Experimental Study on Desulfurization of Zinc Oxide

Zhang Zhonghui^{a*} LI Yong-hui^b

^a Yuxi Normal University, Yu'xi 653100 P.R.China;

^b Kunming University of Science and Technology, Kunming 650607 P.R China;

Abstract. Sulfur dioxide can be eliminated by zinc oxide dust. The process conditions for the direct absorption of sulfur dioxide by the slurry were discussed in this paper. The influence of the variables like the ratio of liquid to liquid, the ratio of liquid to gas, the concentration of SO₂ gas, and the gas velocity on the desulfurization efficiency were investigated. The desulfurization effect of using high-efficiency atomizing nozzle is better than that of vortex nozzle. As the solid content of zinc oxide slurry reaches above 45%, the rate of increase of desulfurization efficiency becomes lower, and even a decreasing trend appears at the later stage.

1 Introduction

With the improvement of people's living conditions in recent years, more and more attention has been paid to environmental requirements. Polluting enterprises are under tremendous pressure from all aspects to conserve energy and reduce emissions. Our country has introduced and absorbed various flue gases to control SO₂ flue gas pollution. As a result of gas desulfurization technology, pertinent domestic engineers have also invented various flue gas desulfurization technologies, which have significantly contributed to our country's emission reduction. The zinc oxide method is the most appropriate desulfurization technology for lead-zinc smelting plants because it uses zinc oxide soot and waste residue produced in the lead-zinc smelting process as a desulfurization absorbent, as well as the desulfurization by-product zinc sulfite or zinc sulfate can be returned to the smelting system for recycling. Not only does it eliminate not need to purchase desulfurized, but it also efficiently recovers the sulfur dioxide in the flue gas, reducing the use of sulfuric acid. The desulfurization system and the production system work together flawlessly [2-4]. The product of the zinc oxide

desulfurization technique is ZnSO₃ • 2.5H₂O, which can be immediately oxidized to ZnSO₄ in the subsequent stage or delivered to an incinerator to be roasted to make acid. In this process, the oxidation of ZnSO₃ demands a considerable amount of oxidizing air and consumes a lot of energy. Many other factors influence the oxidation reaction, and its efficiency is low [1]. Consequently, it is recommended to utilize ZnSO₃ to filter and dry it before sending it directly to the incinerator for roasting to make acid. Due to the high viscosity of the product ZnSO₃ [1], packed towers and plate towers are inappropriate. It is a great option to use vacant buildings for zinc oxide desulfurization. The influencing factors of empty tower zinc oxide desulfurization have been thoroughly studied in this paper.

2 Study on the influencing factors of desulfurization by zinc oxide in an empty tower

In Fig. 1, the experimental process is depicted. Table 1 displays the composition of ZnO-containing fume under the rotary kiln bag filter.

Table 1 Composition of soot containing zinc oxide

	Zn	Pb	Cd	Fe	Cu	S	CaO	MgO	SiO ₂	Others
Contents %	50.87	2.29	0.74	4.64	0.26	1.24	4.42	0.63	4.5	30.41

*Corresponding author: Zhang Zhonghui, lecturer, Email:zhzh@yxnu.edu.cn

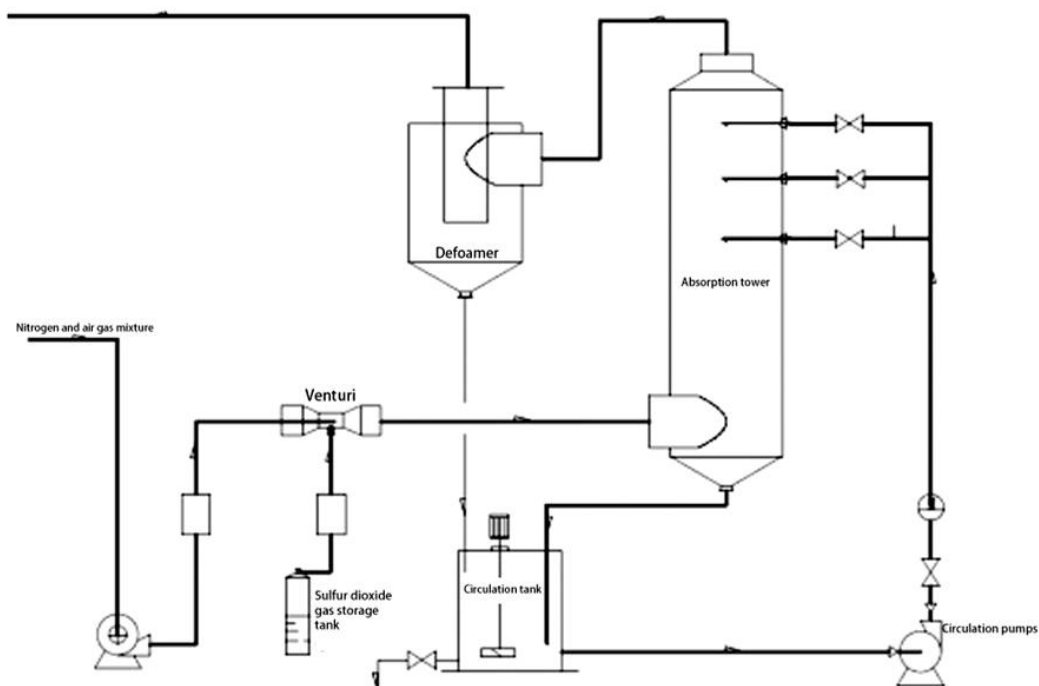


Figure 1 Experimental process flow diagram of zinc oxide desulfurization

2.1 Effect of flue gas flow rate on sulfur dioxide absorption rate

An essential factor affecting the absorption effect is the flue gas flow rate in the absorption tower. The possibility of a reaction between the absorption solution and sulfur dioxide in the flue gas is relatively low because of the high gas velocity and short gas residence time in the building. A better absorption effect could be expected [5]. Figure 2 illustrates the impact of the flue gas flow rate on the sulfur dioxide absorption rate in the suspension concentration of 20% and the inlet gas sulfur dioxide concentration of 1%. According to the influence of flue gas flow rate on sulfur dioxide absorption rate, the higher the air tower gas speed, the lower the absorption rate, which is compatible with the theoretical analysis. Nevertheless, if the gas speed is low, the flue gas treatment volume will be relatively reduced and the cost of the absorption tower will increase. Thus, it needs to choose an appropriate empty tower gas speed based on a different process to satisfy the desulfurization effect requirement in the design. The gas velocity, however, should be controllable. Otherwise, the problem of liquid carryover is severe. This study employed a flue gas flow rate of 1.5 m/s to obtain the optimum desulfurization effect.

2.2 Effect of liquid-gas ratio on sulfur dioxide absorption rate

The liquid-gas ratio is a significant element that influences the absorption rate [5]. Figure 3 below demonstrates the relationship between the liquid-gas

ratio and the sulfur dioxide absorption rate for a specific gas volume and sulfur content. As shown in Figure 3, the sulfur dioxide absorption rate similarly indicates a growing trend with the increase of the liquid-gas ratio, but the growth rate of the absorption rate exhibits a decreasing trend when the liquid-gas ratio reaches a specific value. We can conclude from our research that the best liquid-to-gas ratio is around 100. The increase in the liquid-to-gas ratio corresponds to the rise in absorption surface under the same liquid-to-gas ratio. Increasing the atomization effect of absorption liquid can also increase its surface area. Figure 3 displayed the test outcomes for the identical liquid-to-gas ratio adopting a high-efficiency atomization nozzle and vortex nozzle for comparison. Following the theoretical analysis, Figure 3 shows that the desulfurization impact of using a high-efficiency atomization nozzle (1) is superior to the vortex nozzle (2). Nevertheless, the high-efficiency atomization nozzle is more prone to clogging and the presence of fog foam entrapment is severe because of the tiny effective diameter. This implies that creating a large-diameter effective atomization nozzle is conducive to the development of the zinc oxide desulfurization process.

2.3 Effect of solid-liquid ratio on sulfur dioxide absorption rate

Figure 4 shows the effect of the solid-liquid ratio on the sulfur dioxide absorption rate. The higher the zinc oxide level, the better the desulfurization effect. The higher the zinc oxide content, the greater possibility of contact between sulfur dioxide and zinc oxide, accelerating

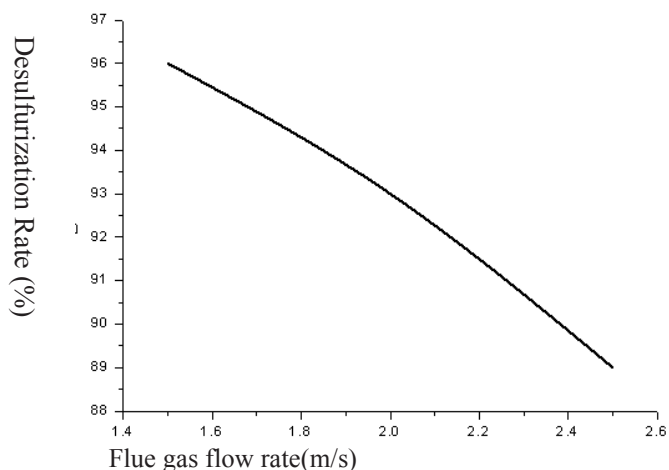


Figure 2 Effect of empty tower gas velocity on sulfur dioxide absorption rate

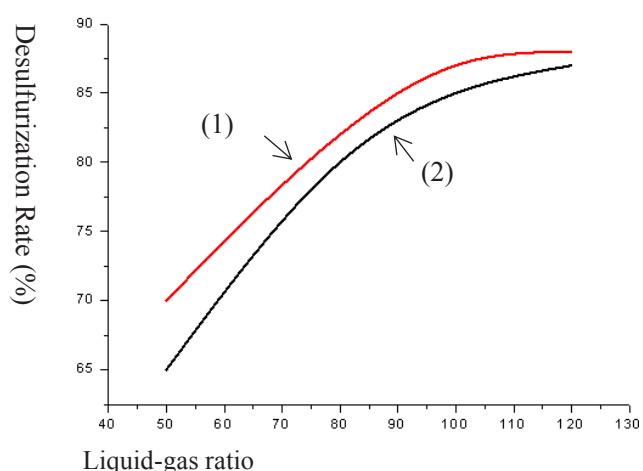


Figure 3 Effect of liquid-gas ratio on sulfur dioxide absorption rate

the reaction to produce zinc sulfite. Moreover, the growth rate in desulfurization efficiency slows down and even a downward trend appears later as the solid-liquid ratio rises by 45%. This is because of the reality that the sulfur dioxide in the flue gas must first be dissolved in water before reacting with solid zinc oxide. Once the solid-liquid ratio reaches a particular value, the solution contains less water and the amount of dissolved sulfur dioxide drops proportionately, thus the sulfur dioxide cannot be dissolved into the aqueous phase to a limited degree and the desulfurization effect is diminished.

2.4 Effect of sulfur dioxide inlet concentration on the absorption rate

The effect of sulfur dioxide inlet concentration on the desulfurization rate is depicted in Figure 5. The absorption rate increases as the inlet sulfur dioxide concentration decreases. Conversely, the absorption rate decreases when the inlet sulfur dioxide concentration rises. In addition, the sulfur dioxide must first dissolve in water before reacting with solid zinc oxide when the concentration of sulfur dioxide in the flue gas is too high. The extra sulfur dioxide cannot dissolve in the aqueous phase. When the concentration of sulfur dioxide becomes too high, the excess sulfur dioxide cannot be dissolved in the aqueous phase. As a result, this part of sulfur dioxide passes directly through the absorption tower, decreasing the absorption effect accordingly. The desulfurization effect can be improved to some extent by increasing the amount of circulating absorption liquid.

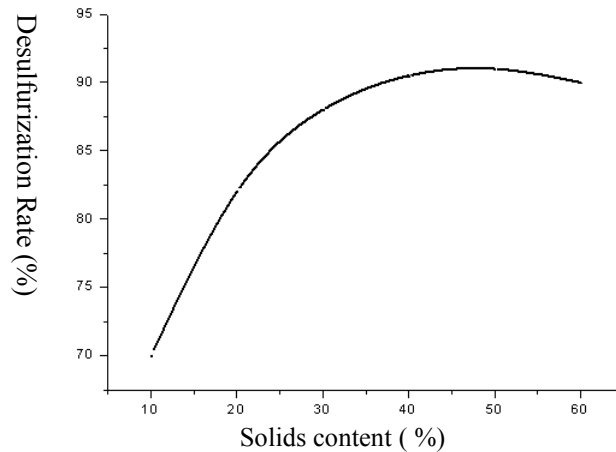


Figure 4 Effect of solid-liquid ratio on sulfur dioxide absorption rate

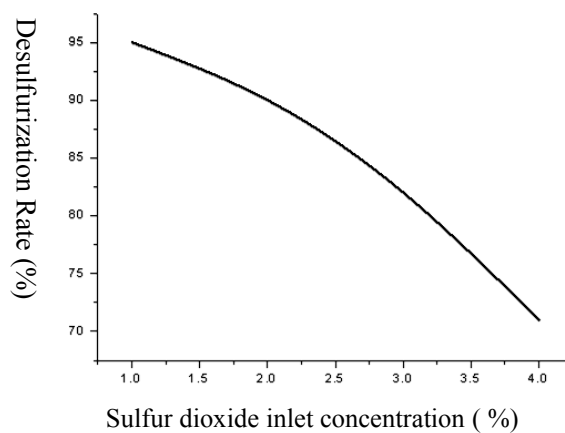


Figure 5 Effect of sulfur dioxide inlet concentration on sulfur dioxide absorption rate

Based on the aforementioned influencing factors and keeping the above variables constant, the authors discovered that the former desulfurization effect is 1-2% higher than the latter when the mill adjusts the absorption liquid phase and the absorption liquid is directly altered by soot stirring.

3. Conclusion

High desulfurization efficiency, low operating costs, comprehensive utilization of the desulfurization products, and absence of secondary pollution are the characteristics of the sulfur dioxide removal process in zinc oxide treatment flue gas. It not only achieves “exhaust gas emission reduction” and “waste reduction” but also realizes sustainable, comprehensive reuse of double waste, which is consistent with the circular economy concept. The effect of desulfurization will be enhanced by well-designed operating parameters. The former has a desulfurization effect that is 1-2% higher than that of the latter by employing the grinding machine to adjust the absorption liquid phase and stirring the absorption liquid directly with dust.

References:

1. Wei Jiaming, Xu Bo, etc. Discussion on the Application of Improved Zinc Oxide

- Desulfurization Process in Zinc Smelter[J] China Nonferrous Metallurgy, Issue 5, October 2010;
2. Ai Yongxin Application of zinc oxide desulfurization in flue gas treatment of volatilization kiln[J]; Hunan Nonferrous Metals, Volume 23, Issue 3, June 2007, P58-60;
3. Nan Xiangli, Zhang Ting'an, Shen Wenchao, Zhang Lu; Study on the absorption of low concentration sulfur dioxide by zinc ash[J]; Proceedings of the Academic Annual Conference of Chinese Society for Environmental Sciences 2011 P 1243-1246;
4. Zhang Junmei The test report on the absorption of flue gas SO₂ by zinc-baked dust slurry and the air oxidation of the absorbed slurry[J]; Fujian Chemical Industry 2002 No. 1 P20-22;
5. Feng Xu, Zhao Suyun, etc. Factors Affecting Desulfurization of Zinc Oxide[J] Chemical Industry and Engineering Technology, Volume 31, Issue 4, August 2010, P31-34;
6. Zhang Zhiling, Liu Gang, etc.; method and device for removing sulfur dioxide from flue gas with zinc oxide, invention patent ZL03104017.9.