AL43 - Modification of Flue Gas Semi-Dry Desulfurization Technology Applied in Primary Aluminium Smelting to Reduce the Consumption of Hydrated Lime Reagent

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Abstract

With the implementation of increasingly strict emission standards, imposed energy-saving and emission reduction policies, the emission concentration limit of flue gas SO_2 in the production process of primary aluminum has been reduced from 200 mg/Nm^3 to 100 mg/Nm^3. To reduce the SO_2 in the flue gas produced by aluminium electrolysis, desulfurization technology has been added to the original flue gas purification system process to achieve the required desulfurization. This paper introduces a primary aluminium smelter using semi-dry desulphurization process. In this application the consumption of reagent to neutralize the captured SO_2 is far beyond the theoretical design value. In addition, the reagent reactions are insufficient resulting in frequent built-up of material inside the desulfurization tower. The material hardens and often falls off the wall causing irregularities in operation. In view of the above, problems are analyzed. It is found that in the flue gas in the desulphurization tower, there is a bias phenomenon. The concentration of SO_2 at inlet was reduced by modifying the defluorination and slag removal tank. The flue gas guide vane was modified to optimize the flue gas flow field and reduce the system resistance. A series of measures, such as optimizing the layout of two-fluid water gun and improving atomization effect, further improved the utilization of reagent, reduce the consumption of reagent, and improve the efficiency of desulfurization.

Keywords: Aluminium electrolysis, Flue gas, Semi-dry flue gas desulfurization, Desulfurization efficiency.

1. Introduction

In primary aluminium production, the flue gas exhausted from the electrolysis cells contains atmospheric pollutants, including fluoride, dust, SO_2 and other species. At present, primary aluminium smelters mainly use an alumina dry adsorption combined with bag dust collector purification process, which can recover most of the fluoride and dust in the flue gas, but the SO_2 cannot be effectively removed.

The SO_2 in the flue gas of electrolysis cells is mainly derived from calcined petroleum coke, the raw material used to make the anode, with a sulfur content of 2 % to 3 % or sometimes higher. Only about 20 % of the sulfur is removed in the calcination process, and 80 % of the sulfur will remain in the calcined petroleum coke. After being mixed in the recipe of the carbon anode, some sulfur is lost in the baking process. After baking, the sulfur in the anode is electrochemically oxidized into carbonyl sulfide (COS) gas and enters the flue gas during electrolysis. The COS gas is instable and reacts with the oxygen in the air to form SO_2. In the alumina dry scrubber the SO_2 is partially absorbed by Al_2O_3, but SO_2 will be re-released when the alumina containing SO_2 is returned to the electrolytic cell. With the sulfur content of 2 % in the anode and the net anode consumption of 420 kg C/t Al, a primary aluminium smelter with an annual output of 500 000 tonnes can emit up to 8400 tonnes of SO_2 per year, which is extremely harmful to the environment.

In recent years, with the rapid development of the domestic Chinese aluminium industry, the demand for carbon anodes has increased, and the low sulfur petroleum coke as a raw material is in short supply resulting is a high price. As a result, anode producing companies have increased the use of high sulfur coke leading to an increase in the sulfur content of carbon anode, and ultimately through aluminum electrolysis flue gas emissions, causing an increase in environmental pollution.

In 2013, on the basis of the "Aluminium Industry Pollutant Emission Standard" (GB25465-2010), the Chinese state issued a more stringent "Amendment to the" Aluminium Industry Pollutant Emission Standard ", which stipulates that the SO_2 emission concentration in key areas is reduced from 200 mg/Nm^3 to 100 mg/Nm^3. Before 2019, the highest measured value of SO_2 in a 500 kA potline was about 140 mg/Nm^3, which met the requirements of the "Aluminium Industry Pollutant Emission Standard" (GB25465-2010). However, there is still a certain gap between the revised "Aluminum industry Pollutant Emission Standards" (2013) with a limit of 100 mg/Nm^3, which means the smelters don’t meet the increasingly stringent environmental requirements. Moreover, to further strengthen the prevention and control of air pollution and to meet the needs of the improvement of the atmospheric environment in the Beijing-Tianjin-Hebei region and its surrounding areas, in 2017, the state issued the Work Plan for the prevention and control of air pollution in the Beijing-Tianjin-Hebei Region and its surrounding areas in 2017, raising the requirements for the prevention and control of air pollution in some areas. Inner Mongolia Autonomous Region requires the implementation of the standard of key areas (SO_2 emission limit of 100 mg/Nm^3), Baotou City in the "Baotou Heavy Pollution Weather Emergency Plan (2020 revision)" requires that the SO_2 emission concentration are stabilized to 35 mg/Nm^3 from November 1 to January 31 of the following year. Therefore, a 500 kA potline began to conduct in-depth treatment of flue gases in 2019 by adding a desulphurization system after the existing gas treatment centre (GTC), and adopting calcium hydroxide ($Ca(OH)_2$) multi-point injection of new semi-dry flue gas desulfurization technology to conduct further treatment of the flue gas after the GTC, effectively removing sulfur dioxide from the electrolytic flue gas and further reducing the total emission of pollutants. With the additional scrubbing system the smelter now meets the existing and future national and local government requirements for environmental protection emission standards, and improve the competitiveness of the aluminium companies.

2. Application of Lime/Gypsum Semi-dry Desulfurization Technology in a Primary Aluminium Smelter

2.1 Process Principle

Lime/gypsum semi-dry desulfurization technology uses hydrated lime (dry calcium hydroxide ($Ca(OH)_2$)) as a desulfurization reagent. This reacts with SO_2 in the flue gas in the desulfurization reactor and the material after the reactions have taken place is separated from the flue gas in the dust collector followed by a discharge into the atmosphere through the chimney. A semi-dry desulfurization process is used because $Ca(OH)_2$ reacts slower with SO_2 under dry conditions. In a semi-dry process, the lime is initially present in slurry droplets for fast absorption. Once the water evaporates the solids turn into dry solids. However, the treatment of desulfurization products in the dry state after it has dried by the heat of the flue gas itself that evaporates the moisture of the absorption liquid while the acid-base reaction is carried out, so that the final product is presented as "dry state".

The researchers apply the understanding that $Ca(OH)_2$, process water and flue gas in the absorption tower mainly carry out the following reactions after the $Ca(OH)_2$ slurry is atomized into small droplets that mix with the flue gases:

1. The first step is the diffusion of SO_2 from the flue gas to the liquid film on the surface of $Ca(OH)_2$ particles that have absorbed the process water;
2. The second step is that SO_2 is absorbed in the liquid film layer;
3. The third step is the dissociation of SO_2 into HSO_3^- and SO_3^{2-};

$$SO_2 + H_2O \leftrightarrow H^+ + HSO_3^- \leftrightarrow 2H^+ + SO_3^{2-} \tag{1}$$

4. The dissociation of $Ca(OH)_2$ into Ca^{2+} and OH^- takes place when the lime is wetted, resulting in bulk concentrations of Ca^{2+} and OH^- that diffuse into the liquid film when the H^+ reacts with OH^- to form water:

$$Ca(OH)_2 \rightarrow Ca^{2+} + 2\,OH^- \tag{2}$$

$$H^+ + OH^- \rightarrow H_20 \tag{3}$$

5. The fourth step is that a fraction of the sulfite is oxidized to sulfate as a result from absorption of O_2 from the flue gases;

$$4H^+ + 2\,SO_3^{2-} + O_2 \rightarrow 4H^+ + 2SO_4^{2-} \tag{4}$$

6. The fifth step, calcium sulfite $CaSO_3 \cdot 1/2H_2O$ is formed which precipitates in solid form;

$$Ca^{2+} + SO_3^{2-} + H_2O \rightarrow CaSO_3 \cdot 1/2H_2O \downarrow \tag{5}$$

7. The sixth step is that gypsum $CaSO_4 \cdot 2H_2O$ is formed;

$$Ca^{2+} + SO_4^{2-} + 2H_2O \rightarrow CaSO_4 \cdot 2H_2O \downarrow \tag{6}$$

The key steps of the reaction are the first and fourth steps, the gas-solid mass transfer process, and the rest of the reaction is completed in an instant.

The completed $Ca(OH)_2$ particles collide with each other under the action of aerodynamic force, resulting in surface collapse, and a new reaction surface is generated, repeating the above reaction. The remaining solid material is ultimately a mix of lime, calcium sulfite, calcium sulfate and other solids like dust and is filtered in the dust collection system from the flue gas stream and deposited. The deposition material will be recycled into the absorption tower for many times, and the freshly added $Ca(OH)_2$ will continuously participate in the reactions and cycle. The addition of water is equally critical since this allows for control over the reaction temperature during the process. The flue gas temperature is closely controlled to a temperature that approaches the adiabatic temperature but is far enough to ensure all material is dry in the filters but that all reactions can take place in a wet environment before evaporation.

2.2 Multi-point Injection Semi-dry Desulfurization Process

The multi-point injection semi-dry desulfurization process uses hydrated lime $Ca(OH)_2$ as the reagent, and the reagent is uniformly sprayed into the desulfurization reaction tower through the multi-point automatic distributor to create a large contact surface for chemical reactions with SO_2 in the flue gas. After the reactions, the flue gas passes through the bag dust collector to collect the solid dust material. The collected desulphurized ash is a mixture of $CaSO_3 \cdot 1/2H_2O$, $CaSO_4 \cdot 2H_2O$, and unreacted $Ca(OH)_2$. The desulphurized ash enters the automatic material separator to extract materials with different densities. The materials with low densities enter the desulphurization tower first for multiple cycle reactions. The desulfurization ash collected by the dust collector is continuously separated and recycled to make the $Ca(OH)_2$ reagent fully react and achieve the best material utilization rate. Desulphurized ash is taken to a storage bin through the conveying system, and finally it is transported to the applied site by the transport vehicle.

2.3 Structure and Technical Characteristics of Multi-Point Injection New Semi-Dry Desulphurization System

New semi-dry desulphurization system process diagram is show in Figure 1.

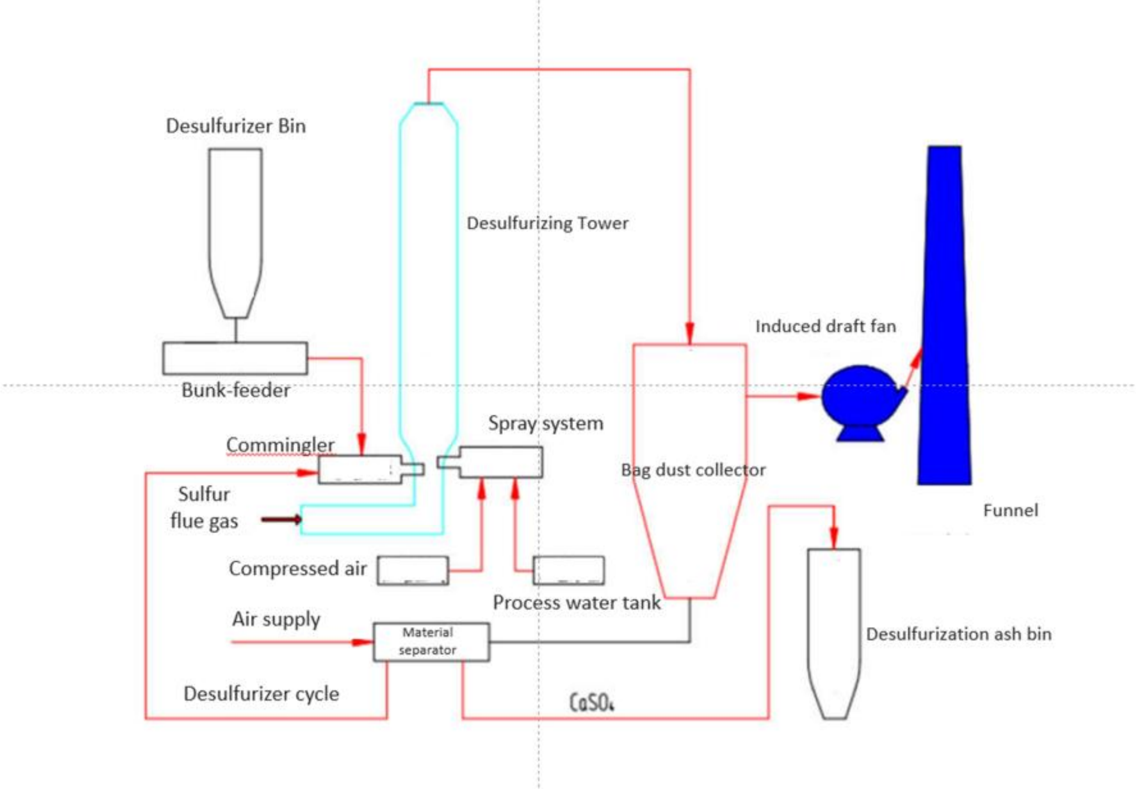

Figure 1. New semi-dry desulphurization system process diagram.

2.3.1 Metering and Transportation

The multi-point injection semi-dry desulphurization system uses an automatic feeding system for feeding the reagent to the tower. In the process of desulfurization system operation, the amount of reagent is automatically adjusted according to the concentration of SO_2 in the flue gas and when the concentration of SO_2 is high, the amount of injected reagent is large, and vice versa as long as the emission concentration of SO_2 in the flue gas is set, the amount of desulfurizer will be automatically adjusted according to the emission concentration. The automatic tracking and adjustment task is completed by the metering device and control system.

2.3.2 Desulfurizing Tower

The design of desulfurization tower should meet the requirements of mass transfer of desulfurization reaction, which is susceptive to inhibiting side reactions, reliable and stable operation, and limited maintenance. When the desulphurization tower has internal components, it often needs to be stopped for cleaning because the material is such that it is easy to occur scaling, blockage, wear and so on. Therefore, the use of internals should be minimized in the desulfurization tower to improve the overall utilization rate of the desulfurization tower. There is no other device inside the desulfurization tower, which makes it an empty tower structure. It can reduce the resistance to flow of desulfurization and save energy on the exhaust fans.

A dust accelerator is set at the bottom of the desulphurization tower to clean up the ash accumulation that occurs under abnormal operating conditions.

2.3.3 Automatic Reagent Dispenser

The reagent required by the desulfurization tower automatically enters the separator, divides into several equal parts of the same quality, and quickly mixes with the flue gas in the desulfurization tower to achieve the best desulfurization efficiency.

2.3.4 Process Water System

The process water system is an important part of desulfurization system, which is composed of a dual-flow atomizing nozzle and control valve frame for regulation of air and water pressures.

The atomizing nozzles are arranged in the desulfurization tower, and the flue gas is cooled and conditioned. The temperature and humidity in the desulfurization tower are very important for the reaction efficiency of SO_2 and reagent in the desulfurization tower. The atomizing nozzle automatically adjusts the spray volume according to the original gas temperature, gas volume, SO_2 concentration and so on, and the control error is less than 2 %. The droplet size leaving the atomizing nozzles is less than 100 µm, which easily evaporates, and can provide for fast reaction conditions.

The function of the control valve frame is to automatically adjust the spray volume of the atomizing nozzle according to the change of the flue gas temperature, gas volume, SO_2 concentration, etc., to ensure that the exit temperature of the desulfurization tower is maintained in a reasonable temperature range. When working, the cooling water is filtered by the filter from the water tank and pressurized by the variable frequency pump and adjusted to a certain pressure and flow rate, and is sent to the atomizing nozzle through the pipeline, atomized under the action of water pressure and compressed air, resulting in fine atomized droplets, which are quickly mixed with the flue gas to achieve the best reaction conditions.

2.3.5 Desulfurization Ash Automatic Separator

The desulphurized ash in the dust collector hopper enters the material separator through the conveying system for density separation, and the material with a lower density enters the circulation system to add to the reagent recycle to improve the utilization rate of the reagent. The separation efficiency of the automatic separator ideally reaches over 90% to ensure the full utilization of reagent, reduce the amount of reagent used overall, and also reduce the amount of desulfurization ash.

2.3.6 Reagent Circulation System

The unreacted $Ca(OH)_2$ extracted by the automatic separator is transported to a buffer bin of the circulating material through the circulating material conveying system. It is then through the multi-point automatic distributor added to the circulating material conveying system to precisely divide into several equal parts and spray into the reaction tower for desulphurization.

2.3.7 Effect on Dust Removal and Defluorination

After the introduction of the flue gas desulfurization system, the whole potline flue gas purification system flow is: alumina dry purification system - desulfurization tower - separation - dust removal system – exhaust fan - chimney. In the process of desulfurization, residual HF and $Ca(OH)_2$ in the flue gas also undergo acid-base neutralization reaction, forming CaF_2 and water, so that the HF in the flue gas is further purified, and the concentration is reduced to 0.05 mg/Nm^3, which is far less than the current standard of Chinese aluminium industry at 3 mg/Nm^3. CaF_2 is part of the desulfurization ash and delivered to the application site in solid form.

3. Key Technical Indexes

The main design technical parameters and indicators of a 500 kA potline desulfurization system are shown in Table 1.

Table 1. Main design parameters and indexes of desulfurization system.

Parameter Type	Units	Parameter Values
Each electrolytic flue gas purification system handles the flue gas volume.	Nm^3/h	1 270 000
Inlet flue gas temperature of desulfurization system.	°C	⩽120
SO_2 concentration of inlet flue gas of desulfurization system.	mg/Nm^3	100-300
SO_2 concentration of flue gas at the exit of desulfurization system.	mg/Nm^3	＜100

The main design technical parameters and indicators of a 500 kA series desulfurization system are shown in Table 2.

Table 2. Main energy consumption table of desulfurization system design.

Inlet flue gas SO_2 concentration （mg/Nm^3）	Reagent consumption （t/d）	Water consumption （t/d）	Power consumption （kWh/d）
200	7.3	355.2	25 200
180	6.4	355.2	24 672
150	5.2	355.2	24 000
120	3.9	355.2	23 400

Since the flue gas desulfurization system was put into operation, the tracking statistics during the operation period from January to July 2022 are shown in Table 3.

Table 3. Main data during operation from January to July 2022.

Parameter Type	Inlet SO_2 (mg/Nm^3)	T Inlet (°C)	T Outlet (°C)	Outlet SO_2 (mg/Nm^3)	$Ca(OH)_2$ Consumption (t/d)	Water consumption (t/d)	Residual $Ca(OH)_2$ in desulphurized ash (%)
Max	334	105	81	81.8	25.1	312	49.8
Min	192	81	59	28.8	20.2	264	29.4
Average	253	93	66	67.9	22.4	288	41.9

As can be seen from Table 3, the maximum SO_2 concentration of inlet flue gas at times is higher than the design value. As a consequence the reagent consumption at the same inlet flue gas SO_2 concentration is also higher than the design value, and the residual $Ca(OH)_2$ in desulfurization ash accounts for a relatively high proportion. After field inspections, it was found that the reagent and ash appeared in the desulfurization tower built-up on walls, hardened, and often falling phenomenon.

According to the SO_2 concentration of inlet flue gas and outlet flue gas, the calculation is made according to the flue gas volume treated by each set of flue gas purification system under working conditions, and using a purity of $Ca(OH)_2$ that is ≥80 %. The theoretical reagent consumption is shown in Table 4.

Table 4. Comparison between theoretical reagent consumption and actual reagent quantity.

Parameter Type	Inlet SO_2 concentration (mg/Nm^3）	Outlet SO_2 concentration (mg/Nm^3)	$Ca(OH)_2$ Theoretical consumption（t/d）	$Ca(OH)_2$ Actual consumption（t/d）	Practical to theoretical difference（t/d）
Max	334	81.8	8.97	25.1	16.15
Min	192	28.8	5.80	20.2	14.44
Average	253	67.9	6.58	22.4	15.83

As can be seen from Table 4, the actual consumption of reagent is much higher than the theoretical consumption, reaching an average of 15.83 t/ day, which equals a factor of approximately 3.

4. Mechanism Analysis of Abnormal Phenomena

4.1 Mechanism Analysis of Increasing SO_2 Concentration in Inlet Flue Gas of Desulphurization System

The mechanism of SO_2 concentration increase in inlet flue gas of desulfurization system is analyzed. SO_2 in electrolysis cell flue gas mainly comes from petroleum coke used in anode manufacturing. The quality of baked anode is analyzed, and the change of S content is shown in Figure 2.

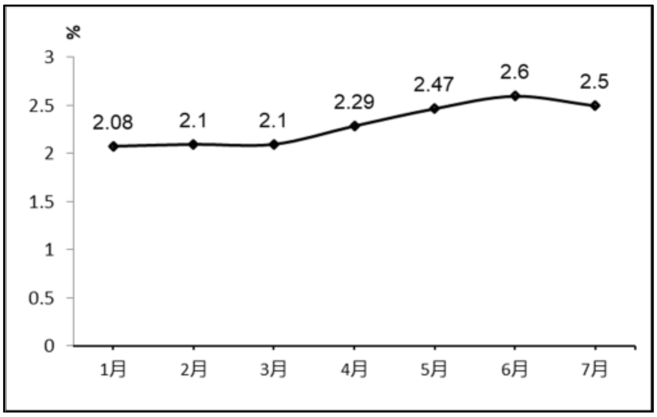

Figure 2. Trend chart of S content in anodes from January to July 2022.

As the S content in the anode continues to increase, the SO_2 concentration in the flue gas at the system inlet increases proportionally.

4.2 The Consumption of Reagent is Much Higher than the Theoretical Value, and The Mechanism of Insufficient Reagent Reaction is Analyzed

4.2.1 Key Factors Affecting Desulfurization Efficiency

4.2.1.1 Effect of Temperature on Reaction

Experiments show that the desulphurization efficiency decreases with the increase of intake temperature T, as shown in Figure 3. This is because the reaction is mainly carried out in the liquid phase, the high water content is conducive to the reaction, and the reduction of T is conducive to the liquid phase maintenance, which can improve the reaction rate. The difference between the flue gas temperature at the outlet of the absorber and the adiabatic saturation temperature, namely the adiabatic saturation temperature difference ΔT (= approach temperature), represents the relative humidity of the flue gas, as shown in Figure 4. A smaller ΔT means that the liquid phase humidity is large, the water vapor evaporation time is prolonged so that more SO_2 is dissolved into the droplets. That said, a too small ΔT is easy to cause flue gas condensation and $Ca(OH)_2$ condensation, resulting in the consequences of sticky material resulting in built-up inside the tower, clogged flues, and blocked filter bags, resulting in an underperforming system. For this reason, it is necessary to control the temperature of the flue gas reaction outlet above the dew point.

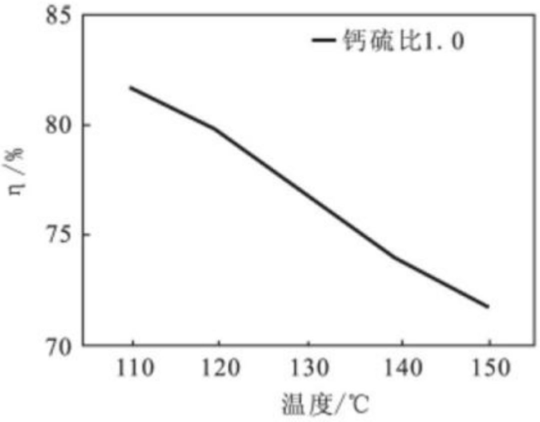

Figure 3. Relationship between desulfurization efficiency and intake air temperature.

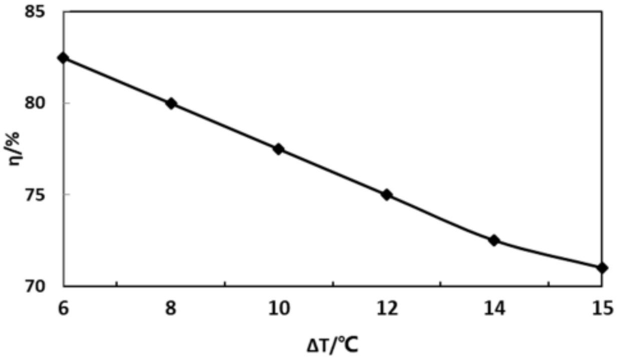

Figure 4. Relationship between desulfurization efficiency and adiabatic saturation temperature difference.

4.2.1.2 Effect of Particle Size of $Ca(OH)_2$ Powder on the Reaction

Experiments show that the smaller the particle size of reagent, the more beneficial to the improvement of desulfurization efficiency, as shown in Figure 5. This is because the reaction is mainly carried out on the surface of the lime particle, and the smaller the particle, the smaller the surface stability energy. After the particle surface reaction, the particle collision is easy to peel off the reaction product calcium sulfite in the turbulent state, and then the reaction will continue. Of course, the particle size of the raw material cannot be infinitely small, too fine material fluidity is poor, easy not to flow caused by hardening, the general requirement of 45 µm or more must be greater than 60 %.

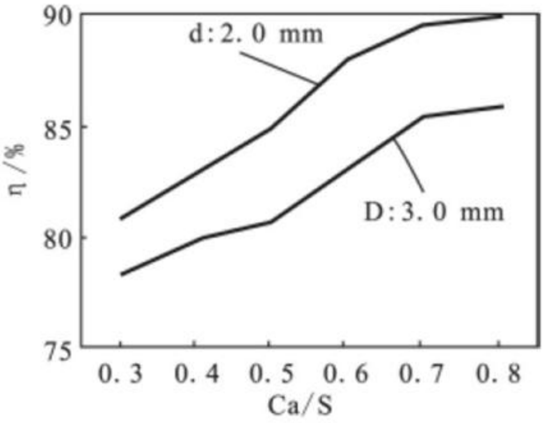

Figure 5. Relationship between desulfurization efficiency and size of reagent.

During operation, it was found that the circulating material was blocked at the feeding mouth, resulting in the circulation material gas lifting not working optimally. During cleaning, it was found that this was caused by the deposition of large particles in the chute. First of all, large particles would make the desulphurization tower uniformly distributed chute material and even blocked, and it would also cause the circulation material to be unevenly distributed in the desulphurization tower resulting in a reduced desulphurization efficiency. At the same time, the desulfurization efficiency is also low because of the decreased specific surface area of large particles.

4.3 Mechanism Analysis of Reagent Accumulating in Desulfurization Tower

4.3.1 The Humidity in Overwet Areas is High

The reagent accumulating in the desulfurizer tower mainly occurs in the ring area on the upper part of the Venturi structure, which is a relatively wet area. The atomized droplets sprayed by the atomizing nozzle have not fully evaporated in the ring area, and the wet reagent mixed with the ash will adhere to the tower wall and eventually form accumulation and built-up.

In experiments we found that when the atomizing nozzle flow rate reached 13 t/h or more, the desulfurizer bonding speed in the desulfurization tower was faster, which is bad.

4.3.2 The Atomizing Nozzle Atomization Effect is Weakened

The flow rate of the dual flow atomizing nozzle is mainly regulated by compressed air, and the impurities in the compressed air will lead to changes in the flow rate. An inspection found that the nozzle of the atomizing nozzle was blocked, which was mainly caused by the impurities in the compressed air after comparative analysis. The compressed air used in the atomizing nozzle is the same as the compressed air source in the potrooms. Because the air is not the same everywhere in the plant, the air pressure often changes, so the flow rate of the spray gun will also change with the change of air pressure.

4.3.3 Flue Gas Turbulence

The desulphurization system is formed in series on the original alumina dry process purification system (GTC) and shares a set of induced draft fans with the GTC. In order to keep the negative pressure of the system unchanged, the original induced draft fan was modified after the addition of desulfurization system. As a result, the flow rate of flue gas entering the desulphurization system increased and turbulence occurred in the desulphurization tower. Because the flue gas distribution is not found to be uniform it results in inadequate reagent reaction.

5. The Process Water System is Modified to Strengthen the Atomization Effect

From the analysis of the above reasons, it can be concluded that after the reconstruction of the induced draft fan the flue gas flow increased whereby the process water system could not meet the reaction of SO_2 and reagent. In order to ensure that the process water in the desulfurization tower can be evenly distributed in the reaction area, and can be reasonably adjusted according to the flue gas conditions, the number of 6 atomizing nozzles are increased to 9 with an average spray angle of 120°. At the same time, key data such as single nozzle flow rate, flue gas temperature and pressure difference of desulfurization tower are imported into PLC system to realize remote real-time monitoring.

In order to deal with the problem of impurities in the compressed air and the unstable pressure, the front filter of the atomizing nozzle system is optimized to remove impurities from the compressed air and reduce the nozzle clogging rate. In order to ensure the stability of the compressed air pressure of the atomizing nozzle, an independent air compressor is added to the atomizing nozzle system, which is used when the air pressure is unstable.

Through the above measures, the atomization effect in the desulfurization tower is much improved, the over-wet conditions are avoided, and the flue gas temperature at the exit of the desulfurization system is reduced by about 5 °C, which provides a great benefit to the desulfurization agent reaction.

6. Optimized Flue Gas Field

According to the flow field test results, when the flue gas flow rate increases, the flue gas in the desulfurization tower appears more turbulent and its uniformity becomes poor, resulting in insufficient local reagent reaction and built-up on the wall of the desulfurization tower. Therefore, improving the uniformity of flue gas field in desulfurization tower can effectively reduce the phenomenon of reagent clogging. Combined with the flow field test, the original guide vane at the flue gas entrance was removed, and a new vane was installed according to the designed position and angle, so that the flue gas was more evenly distributed in the desulfurization tower and the phenomenon of bunching in the desulfurization tower was reduced. The optimized flue gas field is shown in Figure 6.

Figure 6. Optimized flue gas field simulation.

7. Improving the Quality of Reagent

The sample of reagent on site found that the content of $Ca(OH)_2$ in reagent could not meet the contract requirements, and the size of large particles was too big. According to HG/T 4120-2009 industrial calcium hydroxide standard, selected qualified calcium hydroxide, purity was ≥90 %, and particle size to meet the standard requirements (60 % > 45 µm), was 45 µm to 48 µm accounts for 60 %.

8. Implementation Effect

After modifying the process water system of the desulfurization system, optimizing the flue gas flow, and improving the quality of reagent $Ca(OH)_2$, the main operation data statistics are shown in Table 5.

Table 5 Main operation data statistics after transformation.

Parameter Type	Inlet SO_2 (mg/Nm^3)	T Inlet (°C)	T Outlet (°C)	Outlet SO_2 concentration (mg/Nm^3)	$Ca(OH)_2$ Consumption (t/d)	Water rate (t/d)	$Ca(OH)_2$ Theoretical consumption （t/d）	Residual $Ca(OH)_2$ in ash (%)
Max	326	115	85	78.1	24.9	16	8.8	23
Min	282	81	42	25.2	12.5	14	9.1	16
Average	300	101	69	63.1	17.1	15	8.4	18

As can be seen from Table 5, the difference between the actual amount of $Ca(OH)_2$ and the theoretical amount of $Ca(OH)_2$ is 8.7 t/d, and 7.13t/d of reagent is saved compared with that before the modifications, which is a remarkable result.

9. Conclusions

In this paper is presented the addition of a flue gas desulfurization system to existing dry alumina scrubbers in a 500kA potline. The desulfurization system is based on a multi-point injection semi-dry desulfurization process, which effectively reduces the pollutants such as fluoride, SO_2 and dust emitted in the process of aluminum electrolysis production and meets the requirements of national pollutant discharge standards.

In the operation of the desulfurization system, it is found that the consumption of reagent is much higher than the theoretical value, the $Ca(OH)_2$ reaction in the reagent is insufficient, and problems such as built-up of desulfurization ash on walls, clogging and falling sheets are often found in the desulfurization tower wall during maintenance, which increases the workload of maintenance personnel and increases the risk during maintenance. After analysis, the main reasons are as follows:

- The increase of sulfur content in the anode causes the SO_2 concentrations at the inlet of the desulfurization system to exceed the design value, and the atomization effect of the atomizing nozzle in the process water system of the desulfurization tower cannot meet the reaction demand after the increase of SO_2 loads.
- The modification of the induced draft fans of the GTC increased of flue gas flow leading to the turbulence phenomenon after the flue gas enters the desulfurization tower. The uneven flue gas in the reaction area leads to the low reaction efficiency of the reagent.
- The content and particle size of reagent Ca(OH)2 did not meet the requirements of the desulfurization system, resulting in low desulfurization efficiency.

By optimizing the process water system in the desulfurization system, changing the flue gas guide vane, improving the quality of reagent and other measures, the problems were largely solved, and the desulfurization efficiency was improved. Compared with the pre-transformation, the amount of desulfurizer was reduced by 7.13 t/d, and the price of desulfurizer was calculated at 500 ￥/t, which saves the plant 106 900 ￥ per month, and the implementation effect was remarkable.

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