

Application of the Coordination Control Strategy of pH and SO₂ Concentration in the Desulphurization Slurry Supply

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Abstract. The desulphurization slurry flow of the coal-fired unit is usually regulated by a single PID loop that controls the pH value of the gypsum slurry. And the desulphurization system is characterized with large inertia and serious hysteresis, which often results in SO₂ concentration of the outlet exceeding the standard, and leads the operators to turn the regulating valve to manual mode. The SO₂ concentration of the outlet was taken into consideration into the optimized control strategy of desulphurization slurry supply introduced in this paper, and it is with the gypsum slurry pH value for cooperative control of the slurry regulating valve. Finally, the experiment proved that after the optimization of the control strategy, the desulfurization loop could be automatically put into operation for a long time, and the SO₂ concentration of the outlet keeps stable, and the comprehensive utilization rate of limestone and the automation level of auxiliary equipment are significantly improved.

1 Introduction

The desulphurization slurry flow of the power plant is usually regulated by a single PID loop that controls the pH value of the gypsum slurry. This control mode often results in SO₂ concentration of the outlet exceeding the standard, and leads the operators to turn the regulating valve to manual mode. On the one hand, it is easy to cause the SO₂ concentration of outlet fluctuates, the pH value of the slurry high and low, and the desulphurization effect very poor. On the other hand, it also increases the labor intensity of the operators and reduces the automation level of the auxiliary equipment.

In addition, in terms of desulfurization efficiency, high pH value is beneficial to the reaction of SO₂ with limestone slurry, so the desulfurization efficiency is very high. But the experiment proved that when the pH value of slurry was greater than 6.0, the solubility of limestone appears serious decline, which resulted in a large number of particles in tower, the decline of limestone utilization, the increase of operating cost and even the blocking phenomenon in demister, which may lead to unit outage. While the low pH value is beneficial to the increase of limestone solubility, the quality of gypsum is guaranteed. However, when pH value is lower than 4.8, the reaction of SO₂ and limestone solution is suppressed, the desulfurization efficiency is greatly reduced, and the low pH value will aggravate the equipment corrosion. Therefore, it is particularly important to maintain the pH value of limestone gypsum slurry in a reasonable range.

Combined with the related performance test and the operation experience of the FGD system, the pH value of

the limestone gypsum slurry in the desulfurization absorption tower should be kept between 4.8-6.0 [1].

2 The control strategy of desulphurization system

2.1 The control logic of desulphurization system in DCS

The control strategy of slurry flow introduced in this paper is mainly controlled by pH value of the slurry, and the control of SO₂ concentration in the desulphurization outlet is supplemented. The logic scheme is shown in Figure 1.

Firstly, filter the pH1 value and pH2 value of the gypsum slurry, and then take the average as the process value, and the process value minus the set value, and the result is taken as the input of PID1 module, and the output of PID1 controls the slurry regulating valve.

In order to prevent the fluctuation of the SO₂ concentration in the outlet from affecting the supply of the slurry flow, thereby affecting the pH value control, two PID control loops are designed in this optimization scheme. The other way according to the current unit load through the function to calculate the SO₂ concentration set value of the desulfurization outlet, which is compared with the real-time value of the outlet SO₂ concentration, the deviation by the proportional-integral operation (PID2) to control the regulating valve. Through the PID2 loop can be reduced the fluctuation of SO₂ concentration of the desulfurization outlet. The regulation of the PID2 loop is

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also influenced by the deviation between the pH process value and its set value [2~3].

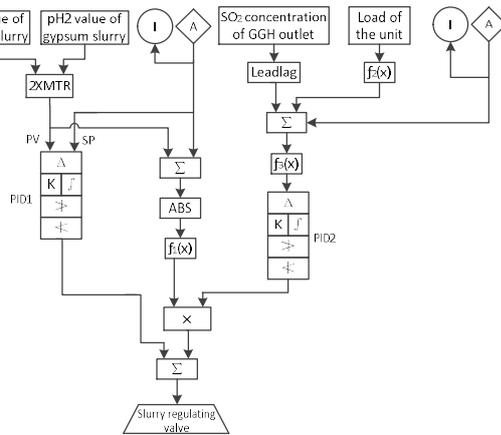


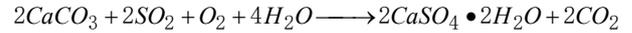
Figure 1. The optimized control logic scheme.

According to the operation statistics of the unit, the SO_2 concentration of the desulfurization inlet increases when the load increases. Therefore, the set value of the SO_2 concentration of the desulfurization outlet could be increased correspondingly with the increase of the load without exceeding the standard. In this way, it is possible to effectively suppress large fluctuation in the supply of slurry flow when the load of the unit is greatly changed, and to provide a stable supply of slurry.

2.2 The practical application of control strategy

A 600MW sub-critical coal-fired condensing steam turbine generator unit put into operation in 1997 was equipped with a 2020t/h coal-fired boiler. In 2006, the unit was added a limestone-gypsum wet flue gas desulfurization unit and the control system adopted Emerson's Ovation system.

When the limestone is used as the absorbent, the simplified chemical reaction of SO_2 in the absorption tower is as follows:



According to the data provided by the manufacturer and the operating rules of the unit, when the pH of the slurry is between 5 and 5.5, the desulfurization effect of the flue gas is the best. Therefore, in order to ensure the continuous and efficient absorption of SO_2 , it is necessary to regulating the slurry supply valve to make the pH of the slurry between 5 and 5.5.

Before modifying the logic, only a single PID control loop was used for the desulfurization control, and the slurry flow was only adjusted by controlling the pH value.

Although the flow control is automatic, the desulfurization efficiency is very low (93%), and the SO_2 concentration of the desulfurization outlet is very high, and the slurry regulating valve swings between 0% and 60%, severely reducing the service life of valve. Also, the pH value of the slurry changes drastically between 4.0 and 6.5, which was not conducive to a sufficient reaction of the limestone solution with SO_2 . Due to the frequent overshoot of the pH value, the operators often adjust manually, and the labor intensity increases. The curve before optimization is shown in Figure 2.

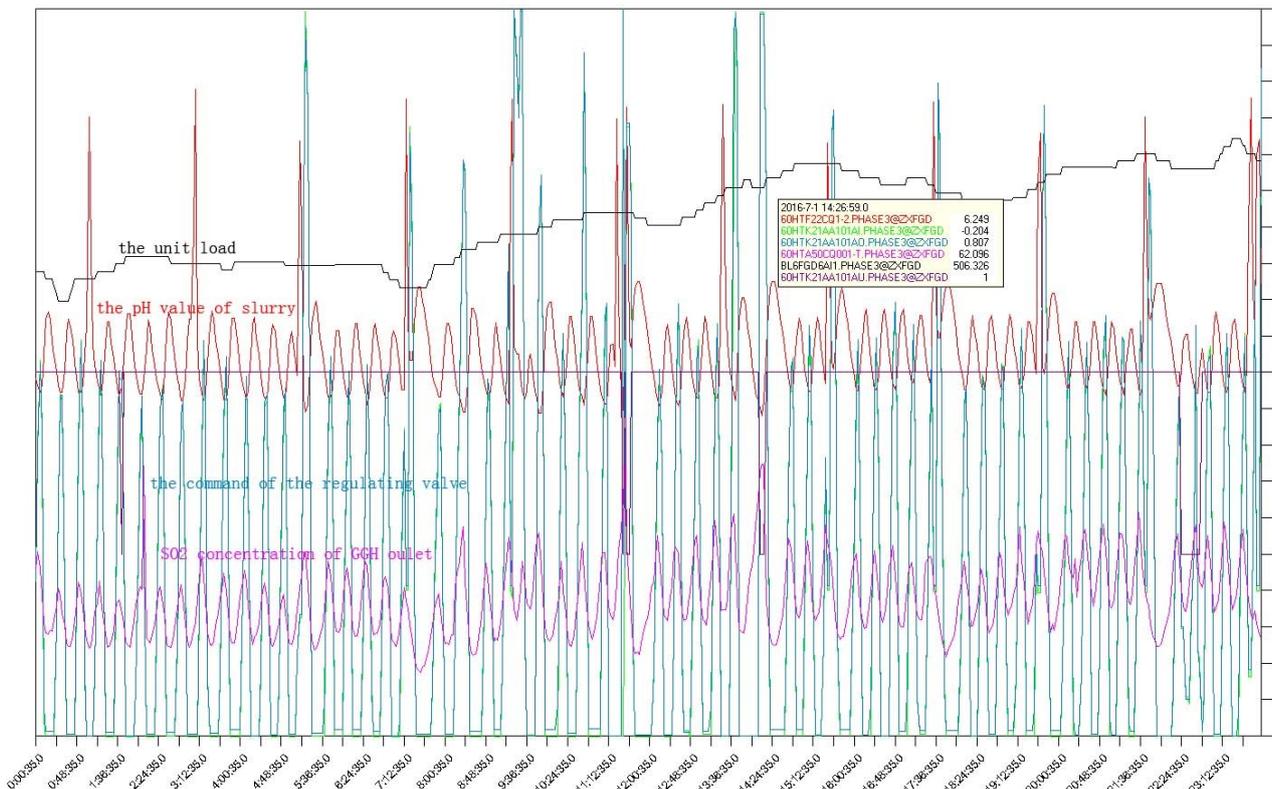


Figure 2. The curve of SO_2 concentration and pH value of slurry before optimization.

The original control strategy was optimized in this paper. Firstly, the pH1 value and pH2 value of the gypsum slurry are averaged as the process value, and the process value minus the set value, and the output of PID1 directly controls the slurry regulating valve. The set value of the SO₂ concentration of the desulfurization outlet could be increased correspondingly with the increase of the load without exceeding the standard. The value of the function f₂(x) in Fig. 1 is shown as Table 1.

Table 1. The parameters of function f₂(x).

x	0	300	400	450	500	550	600	650
f ₂ (x)	0	90	110	130	140	160	170	180

In addition, an offset window has been added to make it easier for operators to make appropriate corrections based on actual conditions. After the function f₂(x) output is subtracted from the GGH outlet SO₂ concentration, it is superimposed with the offset as the input of the function f₃(x). And the value of the function f₃(x) is shown as Table 2.

Table 2. The parameters of function f₃(x).

x	-200	-10	10	200
f ₃ (x)	-200	0	0	200

In order to prevent the supply flow from changing drastically due to the small fluctuation of the SO₂ concentration at the GGH outlet, a dead zone was set in the function f₃(x). The output of function f₃(x) is applied to PID2. The effect of PID2 control loop is affected by function f₁(x), and the absolute value is taken as the input of function f₁(x) after the pH of the slurry is subtracted from the set value. And the value of the function f₁(x) is shown as Table 3.

Table 3. The parameters of function f₁(x).

x	0	0.2	0.3	0.4	0.5	0.6	0.8	1
f ₁ (x)	0.15	0.15	0.1	0.08	0.06	0.04	0.02	0

That is, when the deviation between the pH value of the slurry and the set value is less than or equal to 0.2, the PID2 control loop is multiplied by a factor of 15%. When the deviation is greater than 0.2, the adjustment of the PID2 control loop to the flow of the slurry is getting smaller and smaller until no effect. Finally, the output of the PID2 control loop is multiplied by the coefficient f₁(x) and superimposed on the output of the PID1 control loop to adjust the supply flow of the slurry [4~5].

After optimization, the slurry pH adjustment is as shown in Fig. 3, and the data before and after optimization is shown as Table 4.

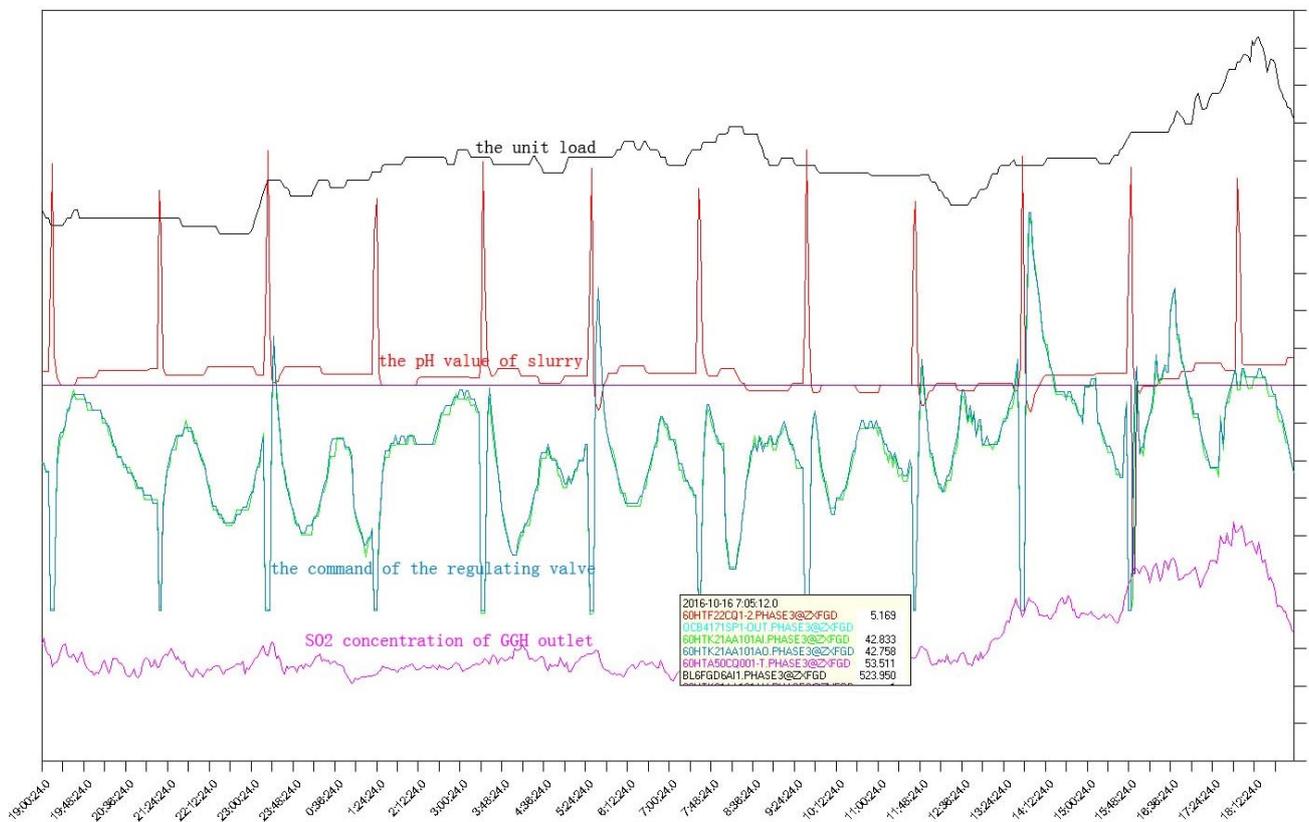


Figure 3. The curve of SO₂ concentration and pH value of slurry after optimization

Table 4. the data before and after the optimization.

	Average unit load (MW)	SO ₂ of inlet (g/m ³)	SO ₂ of outlet (mg/m ³)	Average desulfurization efficiency (%)	PH of slurry	Average slurry flow (m ³ /h)
Before optimization	570.48	1.6621	102.22	93.85	5.61	23.98
After optimization	560.11	1.8457	92.66	94.98	5.49	18.34
Change rate	-1.81%	11%	-9.3%	1.2%	-2.1%	-23.52%

3 Conclusions

Through the optimization of the slurry supply control strategy, the SO₂ concentration of the desulfurization outlet remained stable, and the desulfurization efficiency of the system increased by 1.2%, and the adjustment range of the slurry supply control gate was greatly reduced, which was conducive to extending the service life of the gate. The pH of the slurry could be effectively stabilized between 4.95-5.5, which satisfies the requirement of the manufacturers and is conducive to the full reaction of limestone solution and SO₂, greatly improving the comprehensive utilization of limestone, reducing the total supply of slurry by 23%, and effectively reducing operating costs.

In addition, after the optimization, the average manual intervention frequency of the operators was reduced from 5 times per shift to 0 per shift, which also improved the automation level of the auxiliary equipment.

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