Cause analysis and suggestion of urea consumption in denitrification system of coal-fired power plant

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Abstract. In the daily operation of many power plants, the urea consumption of denitrification system is much more than normal. Therefore, the process of site testing and laboratory analysis are carried out. Several suggestions are given out. (1) The position of sampling hole on the exit flue of denitrification system should be redesigned. (2) The denitrification optimization and adjustment should be carried out based on the technical specifications for the operation system. (3) The flue gas CEMS system for single point sampling should be transformed into two or three point sampling mode. (4) When the coal-fired unit is shutting down, examine the ammonia injection and nozzle branch, in order to improve the operation reliability of denitrification system.

1. Introduction

As an agent used in the flue gas selective catalytic reduction (SCR) system, the urea is widely used in the denitrification system of coal-fired power plants, because of the security advantages. However, in the process of operation, the problems of high energy consumption during urea pyrolysis, urea pyrolysis device crystallization, and denitrification system scaling problems are existed in many coal-fired power plants. In this paper, the denitrification system of 2×210MW power plant is taken as an example. The urea consumption exceeded problem of the denitrification system are tested and analyzed. Based on the results of site testing and laboratory analysis, the design and operation suggestions of denitrification system are proposed in order to improve the operation reliability of the whole system.

A typical coal-fired power plant is shown in Figure 1. The denitrification system is set right after the steam generator to remove NOx from flue gas. In order to improve the reliability of denitrification system in coal-fired power plant, many researches are carried out. Zhiyong Zhao [1] studied the structure and working principle of denitrification system. Several improvements are given out for coal-fired power plants for a better system reliability. Fansheng Zeng [2] indicated different measures for different problems for a better performance. Qingyi Li [3] studied a 1000 MW power plant. The operating status, reliability and stability of denitrification system are thoroughly introduced. However, for different system problems, different improvements should be carried out.
2. Results of the testing and analysis

2.1. Overall assessment of field inspections

To evaluate the condition of denitration system, an examination of the whole system was carried out.

2.1.1. The operation of urea pyrolysis system. The temperature of each node of urea pyrolysis system can be normally and stably controlled. The second wind entrance temperature, the outlet temperature of the electric heater, thermal decomposition chamber entrance temperature, and ammonia injection pipe temperature are in the normal range. The temperature control is very stable. The urea nozzle flow, flow rates and other parameters of ammonia injection pipe can be normal and stable controlled. In the ammonia adjustment, the export concentration of nitrogen oxides can be effectively adjusted.

2.1.2. DCS monitoring data. During the on-site inspection, the outlet NOx concentration of unit #2 A side denitration system was about 10 mg/m³. While the outlet NOx concentration of unit #2 B side denitration system was about 15 mg/m³. The NOx concentration chimney entrance was between 30 to 50 mg/m³. The concentration of NOx in the outlet of the denitrification system is much different from that of the chimney inlet. The problem of "upside down" of NOx concentration is very serious. Through on-site inspection, the sampling points of the flue gas denitration CEMS system in both A and B sides are set only one. Multi sampling points analysis method was not taken.

2.1.3. The concentration of nitrogen oxide in the denitrification system. In order to verify the homogeneity of NOx concentration distribution in unit #2 denitrification system entrance, the nitrogen oxide concentration of different depth in both A and B side entrances were measured on site. Only 4 sampling holes in each side could be used according to the restricted space. The 4 sampling holes are evenly distributed. Therefore, the testing results could represent the whole flue. Test results show that the NOx concentration distribution uniformity of denitrification system in both A and B side entrances are in good situation. The relative standard deviation of the nitrogen oxide concentration distribution in A and B sides were 8.24% and 3.83% respectively. The results are shown in Table 1 and Table 2.
2.1.4. *The concentration uniformity of nitrogen oxides.* In order to verify the homogeneity of NOx concentration distribution in unit #2 denitration system exit, the nitrogen oxide concentration of different depth in both A and B side entrances were measured on site. However, due to the limitation of the field flue space, only half of each side could be measured. Therefore, the results could only tell only half of the flue section. The results are shown in Table 3 and Table 4.

| Thief hatch | Degree of depth | A1 | A2 | A3 | A4 |
|------------|----------------|----|----|----|----|
|            | 0.5 m          | 213.4 | 235.4 | 232.1 | 242.6 |
|            | 1.0 m          | 192.1 | 228.2 | 243.7 | 250.6 |
|            | 1.5 m          | 227.1 | 235.9 | 257.8 | 263.4 |

| Thief hatch | Degree of depth | B1 | B2 | B3 | B4 |
|------------|----------------|----|----|----|----|
|            | 0.5 m          | 226.2 | 229.5 | 216.6 | 207.5 |
|            | 1.0 m          | 227.1 | 215.4 | 220.2 | 211.2 |
|            | 1.5 m          | 232.8 | 224.8 | 224.5 | 208.5 |

Based on the test results, the concentration uniformity of nitrogen oxides in the denitrification system exit is poor. The relative standard deviation of the nitrogen oxide concentration distribution in B side was 50.21%, which is much more than the recommended indicator of 20%. The highest concentration of nitrogen oxides was 44.5 ppm and 91.4 mg/m3, which is much more than the controlling standard of 50 mg/m3. The unit conversion of nitrogen oxides concentration is listed in equation (1).

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C_{mg/m^3} = \frac{46}{22.4} C_{ppm}
\]  

(1)
The relative standard deviation of the nitrogen oxide concentration distribution in A side was 15.75%, which is a little better than that of B side. The specific distribution of the other half of the flue is unknown, due to the limitation of the field flue space.

2.1.5. The manual regulating valves of ammonia spraying grid. Since the start of the unit, the denitration system has never been optimized. The manual regulating valves of ammonia spraying grid are all in fully open state. The optimization of ammonia spray distribution has never been carried out.

2.2. Causes analysis
The reason for high urea consumption is the uneven of the ammonia injection grid. Because of the differences of the entrance nitrogen oxide distribution, the activity of catalyst layer, the blockage of catalyst layer, the flue gas velocity distribution and other specific factors, the required amount of ammonia spray is different in each part of denitration system section. The differences of nitrogen oxide concentrations in the denitrification system exit and the chimney exit, and the poor concentration uniformity of nitrogen oxides in the denitrification system exit, showed that the ammonia injection distribution is much different from the requirement. Therefore, the concentrations of nitrogen oxide in some sections are seriously exceeded, while the concentrations of ammonia escape in other sections are seriously exceeded. Afterwards, the problems of high NOx concentration in the chimney entrance and the high consumption of urea will be taken place.

3. Suggestions
To get a more reliability and stability denitrification system, suggestions are listed.

(1) The position of sampling hole on the exit flue of denitrification system should be redesigned. The sampling holes are evenly distributed on both A and B sides of the flue section. The detect and analysis the distribution of nitrate nitrogen oxide and ammonia escape should be easily carried out.

(2) The denitrification optimization and adjustment should be carried out regularly based on the technical specifications for the operation system [4].

(3) The analysis of the ammonia escape concentration should be carried out regularly based on the technical specifications for the operation system [4].

(4) The flue gas CEMS system for single point sampling should be transformed into two or three point sampling mode.

(5) When the coal - fired unit is shutting down, examine the ammonia injection and nozzle branch, in order to improve the operation reliability of denitration system.

4. Conclusions
Denitrification system is an important part in coal-fired power plant. NOx could be removed from flue gas. However, there are many problems in the process of production. This paper analyzed a 2×210MW power plant. The specific problems and measures are introduced. Based on the proposed improvement measures, the coal-fired power plant could acquire a more reliability and stability denitration system.

References
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