Reasons analysis of the large deviation in the NO\textsubscript{x} emission data of the coal-fired power plant

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Abstract. The problem of the large deviation in the CEMS (Continuous Emission Monitoring System) data of NO\textsubscript{x} emission from the coal-fired power plant is analyzed. The deviation existed between the data measured at the chimney and the outlet of the denitration system. On-site inspection and testing are carried out. The results show that the uneven distribution of NO\textsubscript{x} concentration at the denitration outlet caused by the uneven ammonia injection, is the main reason for the difference in the NO\textsubscript{x} concentration monitoring value between the chimney inlet and the outlet of the denitration system. Several suggestions are given to reduce the deviation between the CEMS monitoring data and the actual average data. In the subsequent operation of the denitration device, AIG ammonia injection optimization and adjustment tests should be carried out regularly. The ammonia injection branch pipes and nozzles should be checked, especially at the shutdown time.

1. Introduction

CEMS (Continuous Emission Monitoring System) is an important online device for real-time monitoring of the air pollution emissions data from coal-fired power plants. The data validity of CEMS is particularly important.

After a 660MW coal-fired power plant started up, there is a large deviation in the CEMS data of NO\textsubscript{x} emission. The average NO\textsubscript{x} concentration at the outlet of denitration system is 12-18mg/m\textsuperscript{3} (normal condition and 6% of O\textsubscript{2} content) higher than the average NO\textsubscript{x} concentration at the chimney inlet. One week later, the deviation disappeared. One month after that, the average NO\textsubscript{x} concentration at the outlet of the denitration is 10-20mg/m\textsuperscript{3} (normal condition and 6% of O\textsubscript{2} content) lower than the average NO\textsubscript{x} concentration at the chimney inlet.

During the large deviation, various measures such as steam soot blowing, changing the dilution air volume, and adjusting the combustion mode were carried out. However, the long-term effect was not obvious.

The on-site inspection and testing will be carried out. The cause of occurrence will be analyzed. The recommendations and protective measures will be given out to prevent further problems.

2. On-site testing

There is no abnormality in the equipment and operating conditions of the denitration system, and the CEMS system is working normally. However, there is only one extraction sampling hole for CEMS in
the middle of one side of the flue. The extracted flue gas is processed and sent to the CEMS system for component analysis. There is no multi-point extraction and mixing analysis.

2.1. Experiment method
The NOx concentration distribution detection test is to arrange the points at the exit flue section of the denitration system [1] according to the grid method, which is a standard method to insure the impartiality of the data. The flue gas samples are draw out from the flue point by point and sent to the flue gas analyser with rubber tube to analyze the flue gas components. The flue gas analyser is based on non-dispersive infrared absorption method. Before the test, the flue gas analysis system is calibrated with standard gases. After the test, the flue gas analysis system performs a drift check.

The flue gas velocity distribution detection test is used a calibrated standard pitot tube to measure the flue gas velocity at each point of the flue section at the outlet of the denitration system [2], using the grid method to obtain the flue gas velocity distribution.

2.2. Testing point
There are two test points at the outlet of the denitration system, which are located at the lower part of the catalyst layer and the inlet flue of the air preheater [3]. The schematic diagram of testing points is shown in Figure 1. The flues are arranged on both sides of A and B, which are two branches of flue with respective SCR (Selective Catalytic Reduction) reactor, air preheater, filter and desulfurization absorber. Among them, the test point of the lower part of the catalyst is the original design test point of the boiler plant, which is arranged on the adjacent side walls of the flue on both sides of A and B. There are 11 measuring holes on each side, which are marked as 1 to 11 respectively. The schematic diagram of flue plan is shown in Figure 2.

![Figure 1. Schematic diagram of testing points.](image-url)
2.3. Testing conditions
The test is selected under the normal operating load of 330MW, which is the most used operating load. During the test, no work that interferes with the operation of the boiler is performed, such as soot blowing, coking, changing the operation mode of the pulverizing system, etc. The boiler operating parameters are kept stable [4].

2.4. Results
Under the working condition of the unit load of 330MW, the distribution of NOx concentration at the denitration outlet of the flue A side and B side were tested respectively. The test results are shown in Table 1. The test results show that the NOx concentration distribution at the outlet of the denitration system is uneven. The relative standard deviation of NOx concentration distribution in side A flue is 70.70%, and the relative standard deviation of NOx concentration distribution in side B flue is 42.92%.

Table 1. Test results of NOx concentration distribution at the outlet of the denitration system.

| Flue measuring hole | NOx concentration (mg/m3) (normal condition and 6% of O2 content) |
|---------------------|---------------------------------------------------------------|
|                     | Side A             | Side B             |
| 1                   | 37.63              | 16.61              |
| 2                   | 21.56              | 12.86              |
| 3                   | 12.59              | 3.35               |
| 4                   | 14.33              | 6.29               |
| 5                   | 28.26              | 21.56              |
| 6                   | 60.67              | 11.52              |
| 7                   | 29.60              | 7.63               |
| 8                   | 21.70              | 9.38               |
| 9                   | 33.48              | 15.40              |
| 10                  | 67.63              | 13.53              |
| 11                  | 104.33             | 15.00              |
| Average             | 39.25              | 12.10              |
| Relative standard deviation | 70.70             | 42.92              |

The air sampling hole of the CEMS system on side A is located near the top of the 5th measuring hole. From the test results in Table 1, the NOx concentration detection value of the No. 5 measuring hole on side A is 10.99mg/m^3 (normal condition and 6% of O2 content) lower than the average value of each measuring hole. Side B CEMS system gas sampling hole is located near the top of No. 6
measuring hole. From the test results in Table 1, the NO\textsubscript{x} concentration detection value of No. 6 measuring hole on side B is 0.58mg/m\textsuperscript{3} (normal condition and 6% of O\textsubscript{2} content) lower than the average value of each measuring hole. Meanwhile, the NO\textsubscript{x} concentration detection values of No. 5 borehole on side A and No. 6 borehole on side B are consistent with the CEMS monitoring data.

Under the working condition of the unit load of 330MW, the flow velocity distribution of the denitration outlet flue gas on the side A and B were tested respectively. The test results are shown in Table 2. The test results show that the flue gas flow velocity distribution in the exit flue section of the denitration system is relatively uniform, in which the relative standard deviation of the flue velocity distribution on the side A and B are 2.57% and 2.93%, respectively.

| Table 2. Test results of flow velocity distribution of flue gas at the outlet of denitration system. |
|-----------------------------------------------|
| Flue measuring hole | NO\textsubscript{x} concentration (m/s) | Side A | Side B |
| | 0.5m | 1.0m | 1.5m | 0.5m | 1.0m | 1.5m |
| 1 | 10.1 | 10.2 | 10.3 | 9.4 | 9.5 | 9.5 |
| 2 | 10.0 | 10.2 | 10.2 | 9.7 | 9.7 | 9.8 |
| 3 | 9.8 | 10.1 | 10.3 | 9.9 | 10.0 | 10.2 |
| 4 | 9.9 | 10.3 | 10.5 | 9.5 | 9.8 | 9.8 |
| 5 | 10.2 | 10.6 | 10.8 | 9.2 | 9.5 | 9.4 |
| 6 | 10.3 | 10.4 | 10.6 | 9.1 | 9.2 | 9.0 |
| 7 | 10.4 | 10.5 | 10.4 | 9.2 | 9.1 | 9.2 |
| 8 | 10.6 | 10.7 | 10.6 | 9.3 | 9.3 | 9.5 |
| 9 | 10.7 | 10.8 | 10.9 | 9.4 | 9.6 | 9.8 |
| 10 | 10.6 | 10.6 | 10.7 | 9.5 | 9.7 | 9.7 |
| 11 | 10.5 | 10.6 | 10.5 | 9.4 | 9.5 | 9.4 |
| Average | 10.42 | 9.51 |
| Relative standard deviation | 2.57 | 2.93 |

3. Discussion and analysis

The NO\textsubscript{x} concentration is pretty even at the chimney inlet, because of the well mix after going through the dust removal system and the desulfurization system. The uneven distribution of NO\textsubscript{x} concentration at the denitration outlet caused by the unmatched ammonia injection, is the main reason for the difference in the NO\textsubscript{x} concentration monitoring value between and the outlet of the denitration system. The relative standard deviations of the NO\textsubscript{x} concentration distribution of side A and side B are 70.70% and 42.92%, respectively. The NO\textsubscript{x} concentration value of the 11th hole on the A side reaches 2.66 times the average value. The NO\textsubscript{x} concentration value of the 5th hole on the B side reached 1.78 times the average value. The concentration value deviated seriously. Moreover, the main reason for the uneven distribution of NO\textsubscript{x} concentration at the denitration outlet is caused by unmatched distribution of ammonia injection.

The flue gas sampling point of the CEMS system is only a single point sampling. At the exit flue of the denitration system on side A and side B, only one extraction sampling point of the CEMS system is set, which is located at the horizontal center of the front wall of the flue. The test results show that the NO\textsubscript{x} concentration detection value of the measuring hole near the sampling point on side A is 10.99 mg/m\textsuperscript{3} (normal condition and 6% of O\textsubscript{2} content) lower than the average value of the measuring hole on side A. The NO\textsubscript{x} concentration detection value of the measuring hole near the sampling point on side B is 0.58mg/m\textsuperscript{3} (normal condition and 6% of O\textsubscript{2} content) lower than that of the average on side B. The monitoring result of the CEMS system is the NO\textsubscript{x} concentration value at this point, which represents the average value of the NO\textsubscript{x} concentration at the exit flue section of the denitration system. The data results of single-point sampling are less representative. Compared with the sampling method of mixed analysis with two-point or three-point sampling, single-point sampling is more susceptible to
factors such as the uneven distribution of NO\textsubscript{x} concentration at the outlet of the denitration system. Therefore, the monitored value makes a bigger difference with the actual averaged value.

The CEMS NO\textsubscript{x} display value at the outlet of the denitration system is accurate, based on the system maintenance. The CEMS analysis system and monitoring data are deviated from the true average data. The test results show that the NO\textsubscript{x} concentration detection values of the measuring holes near the sampling points on side A and side B are consistent with the CEMS monitoring data. The CEMS system works normally.

The flue gas flow rates at the denitration outlets on side A and side B are relatively uniform, which basically has no effect on the nitrogen oxide monitoring data of the CEMS system. The test results show that at the exit flue section of the denitration system, the relative standard deviation of the flow velocity distribution on side A and B are 2.57\% and 2.93\%, respectively. The flue gas flow velocity distribution is relatively uniform.

4. Conclusions and suggestions

On-site testing is carried out. The reason for the large deviation in the NO\textsubscript{x} emission data is analyzed. The uneven distribution of NO\textsubscript{x} concentration at the denitration outlet caused by the unmatched ammonia injection, is the main reason for the difference in the NO\textsubscript{x} concentration monitoring value between and the outlet of the denitration system.

In the subsequent operation of the denitration device, AIG (Ammonia Injection Grid) ammonia injection optimization and adjustment tests should be carried out regularly. The amount of ammonia injection should be optimized according to the NO\textsubscript{x} concentration distribution characteristics of the flue gas in the reactor. The distribution of the ammonia injection amount at the flue section will be more reasonable, to ensure the NO\textsubscript{x} concentration distribution at the SCR outlet.

When conditions permit, the single-point sampling of the flue gas of the CEMS system could be transformed into a two-point or three-point sampling method. After the multi-point sampling is applied, the uneven distribution of NO\textsubscript{x} concentration could be reduced. The deviation between the CEMS monitoring data and the actual average data could be reduced.

Using the differential pressure before and after the orifice plate flowmeter at each ammonia injection branch pipe, the ammonia injection flow rate of each ammonia injection branch pipe could be checked and calculated one by one. The ammonia injection branch pipes and nozzles should be checked, especially at the shutdown time, to avoid any blockage. The branch pipes with high NO\textsubscript{x} concentration should be checked especially.

References

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