2×130t/h Coal-fired Boiler white plumes removal solution

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Abstract. This report discusses the formation and main technical routes of current white plumes solutions. Through the comparative analysis of the technical routes, condensing and reheating system is recommended for this 2×130t/h coal-fired boiler project. The technical solution and calculation are also suggested for this project.

1. Introduction
At present, domestic power plant boilers mostly use the wet flue gas desulfurization (Wet-FGD) [1] process, and the flue gas after FGD is in a saturated state. The saturated wet flue gas discharged from the chimney is in contact with the ambient air with lower temperature. With the temperature drop, the water vapor in the flue gas is supersaturated [2-3], condensed, scatter around and this is how the white plume or the thermal engineers called "wet plume" appears.

The cause of wet plume is clearly correlated with ambient temperature and relative humidity. In summer, due to the high temperature, the probability of wet plume is low; while in winter, because of the low temperature, wet plume is more likely to occur. The droplets carried by the wet flue gas contain a large amount of salts, and the water droplets in the exhaust flue gas will evaporate and produce a large amount of salt particles with a small particle size, which has a negative impact on the environment.

In Shanghai, Zhejiang, Tianjin, Handan and other places, the government has issued local standards for eliminating white plumes, which push the power plants to find solutions and install related equipment.

2. The current technical solution of white plumes
Generally, there are three main technical solutions for white plumes:

(a.) Direct heating.
(b.) Condensing at the FGD outlet and then reheat the flue gas.
(c.) Cooling the FGD outlet flue gas to a lower temperature.
According to Figure 1, the direct heating technology needs lots of heat resource which are generally from hot secondary air in boiler or the steam form turbines, which both affect the net power generation a lot because at the chimney outlet usually the flue gas temperature shall be more than 80℃. This solution is recommended in places with heat demand area. While the cooling method is easy but will consumes lots of cooling water. In gross calculation, the cooling water amount for white plume removal will be 1/10 to 1/8 of cooling tower recycled water. The condensing and heating solution seems most proper in the three.

3. The project information and solution proposal

3.1. Project Information

The project is in Henan Province and 2 × 130 t/h CFB boiler will be installed in this project. The pollutant emission control for SOx, NOx and TSP is 35mg/Nm³, 50mg/Nm³ and 5mg/Nm³ correspondingly. It is requested to install white plume removal equipment.

To meet the requirements, limestone-gypsum wet FGD and Selected Catalyst Removal for NOx are designed for this project.

The main design data is as in Table 1.

### Table 1. The main design data

| No. | Item                                      | Data             | Unit |
|-----|-------------------------------------------|------------------|------|
| 1   | Flue gas flowrate                         | 217100           | m³/h |
| 2   | Flue gas T at outlet of ID fan             | 151              | ℃    |
| 3   | Flue gas T at FGD outlet                  | 54               | ℃    |
| 4   | Flue gas T after condensation             | 45/48(Winter/Summer) | ℃    |
| 5   | Chimney discharge T                       | 60/54(Winter/Summer) | ℃    |

3.2. Solution proposal

According to the actual situation of local ambient temperature, the technical solution is a flue gas cooling (condensation) and reheating technology. The flue gas condensation and reheating technology first...
reduces the flue gas temperature of the FGD outlet to 45 °C (winter) / 48 °C (summer), and then heats up to 61.5 °C (winter) / 63.5 °C (summer), which can remove white plume with winter ambient temperature of 12 °C and relative humidity of 0.6, as well as with the summer ambient temperature of 19 °C, and relative humidity of 0.8, which helps to meet the requirements of local standards. The heat required for reheating of the flue gas comes from the heat of the original flue gas before desulfurization, and the cold source required for flue gas condensation is taken from the circulating water of the cooling tower.

3.3. The flow diagram of white plume removal system

The flue gas from ID fan is firstly cooled and the calorie is reused to heat up the FGD outlet flue gas to 65°C. The flue gas at outlet temperature is around 50°C and is further cooled by flue gas condensation heat exchanger to 45°C where most of water vapor is condensate and goes back to FGD absorber finally. And then the flue gas is reheated to 65°C where the two heat exchangers works as MGGH in power plant.

During the cooling process of the wet flue gas, the water vapor condenses and changes phase with the fine particles as the core. The small particles become large particles and are captured and collected by the heat exchange tube bundle. Therefore, the heat exchanger tube bundle also works as the dust removal equipment during the water vapor collection process. The dust removal efficiency of the flue gas condensing heat exchanger reaches more than 50% [2].
3.4. The main calculation results of the white plume removal system for this project in Winter

Table 2. The main calculation results in winter

| No. | Item                          | Data     | Unit   |
|-----|-------------------------------|----------|--------|
| 1   | Flue gas flowrate             | 217100   | m³/h   |
| 2   | Flue gas cooling in/out T     | 151/133  | °C     |
| 3   | Flue gas reheat in/out T      | 45/61.5  | °C     |
| 4   | Recycling water in/out T      | 100/113  | °C     |
| 5   | Recycling water flowrate      | 65       | t/h    |
| 6   | Recycling water heat exchange | 963      | kW     |
| 7   | Flue gas condensation in/out T| 54/45    | °C     |
| 8   | Flue gas condensation water in/out T | 20/30.65 | °C |
| 9   | Flue gas condensation water side flowrate | 350 | t/h |
| 10  | Water condensate amount       | 5.71     | t/h    |
| 11  | Flue gas side flow resistance | 850      | Pa     |

3.5. The main calculation results of the white plume removal system for this project in Summer

Table 3. The main calculation results in winter

| No. | Item                          | Data     | Unit   |
|-----|-------------------------------|----------|--------|
| 1   | Flue gas flowrate             | 217100   | m³/h   |
| 2   | Flue gas cooling in/out T     | 151/133  | °C     |
| 3   | Flue gas reheat in/out T      | 48/63.5  | °C     |
| 4   | Recycling water in/out T      | 100/113  | °C     |
| 5   | Recycling water flowrate      | 65       | t/h    |
| 6   | Recycling water heat exchange | 963      | kW     |
| 7   | Flue gas condensation in/out T| 54/38.86 | °C     |
| 8   | Flue gas condensation water in/out T | 32/38.86 | °C |
| 9   | Flue gas condensation water side flowrate | 350 | t/h |
| 10  | Water condensate amount       | 3.7      | t/h    |
| 11  | Flue gas side flow resistance | 850      | Pa     |

3.6. The general power consumption

Table 4. The general power consumption

| No. | Item                                                   | Data | Unit |
|-----|--------------------------------------------------------|------|------|
| 1   | The recycling cooling water pump                      | 9    | kW   |
| 2   | Cooling water for condensation at FGD outlet           | 48   | kW   |
| 3   | ID fan increased Power consumption                     | 64   | kW   |

4. Conclusion
The condensing and reheating technology is applied to the flue gas treatment system, which can basically eliminate the white plume problem and meet the requirements of local standards. At the same time, flue
gas condensate can remove most of the salt and SO₃ in the wet flue gas, and has more than 50% dust removal efficiency. The condensate and reheat solution is proposed for the 2×130t/h boiler.

References
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