Research on Optimization of Flow Field of Denitration System of 600MW Unit and Modification of Fine Ammonia Injection

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Abstract. Aiming at the uneven distribution of flow field in the denitration system of coal-fired power plant boilers, poor mixing of ammonia and nitrogen, increased ammonia escape, and easy blockage of the air preheater, a flow field optimization and transformation plan was proposed through numerical simulation and added in the flue of the denitration system. Equipped with baffles and static mixers, modified the ammonia injection pipeline in zones, implemented ammonia injection total control and grid balance automatic adjustment control. After the transformation of precise ammonia injection for denitrification, the NOx emission of the unit is stably controlled at 40 mg/Nm³, the steady-state deviation value and other indicators are better than the acceptance standard, and the air preheater differential pressure is effectively controlled.

1. Introduction
The nitrogen oxides generated during the combustion of coal-fired power station boilers seriously harm the ecological environment and become one of the main control indicators for boiler flue gas pollutants. The technologies for controlling nitrogen oxide emissions in coal-fired power plant boilers are divided into two categories: one is low-nitrogen combustion control technology, which controls the generation of thermal nitrogen oxides from the source; the other is flue gas purification technology, which mainly includes selective Non-catalytic reduction (SNCR) technology and selective catalytic reduction (SCR) technology, etc [1-3]. SCR technology is most widely used in coal-fired power station boilers due to its high denitration efficiency and reliable operation. In recent years, domestic coal-fired units have generally implemented "ultra-low emission" retrofits, and the emission concentration of nitrogen oxides is controlled within 50 mg/m³ [4-5]. Some key areas have put forward stricter emission requirements. Under this situation, the SCR denitification system often has the phenomenon of inaccurate ammonia injection control and uneven flow field distribution, resulting in partial ammonia escape and NOx emission concentration that cannot meet the requirements. Power plants often increase the amount of ammonia injection to maintain overall NOx emissions at the outlet. As a result of the increase in ammonia escape, the probability of the formation of ammonium bisulfate (ABS) is also greatly increased, resulting in the clogging of ammonium bisulfate and contamination of downstream equipment such as air preheaters. The NOx emission requirements are different, and the problems in the SCR system are also different. It is possible to improve the efficiency of denitification, reduce the consumption of ammonia, and reduce the occurrence of equipment clogging and contamination by precise injection of ammonia for denitrification. This research takes the SCR denitification system of a 600MW ultra-
supercritical coal-fired generating unit boiler in a certain power plant as the object. Through numerical simulation, an optimized transformation plan is proposed. A mixer is installed in the flue of the SCR denitrification system, and the ammonia injection pipeline is modified in zones. The total amount of ammonia injection and the grille balance control can improve the denitrification efficiency and reduce the ammonia consumption to avoid problems such as equipment blockage [6-7].

2. Introduction to denitrification system
The denitrification device is mainly divided into two areas: reaction zone and ammonia zone. The reaction zone mainly includes reactor, flue, dilution fan, etc. The flue is led out from the outlet of the boiler economizer, connected to the reactor and connected from the upper part of the air preheater. The flue gas denitrification device is installed between the outlet of the boiler economizer and the inlet of the air preheater, and the SCR reactor is installed on the framework platform above the operating layer platform on both sides of the boiler. SCR auxiliary equipment (dilution fan, mixer, soot blower, etc.) are arranged on the reactor platform. The NH3 sprayed into the flue gas at a certain ammonia-nitrogen molar ratio undergoes a chemical reaction with the NOx in the flue gas under the action of the denitration catalyst, so as to achieve the purpose of reducing the NOx content in the exhaust smoke. The main equipment in the ammonia zone includes liquid ammonia discharge compressor, ammonia storage tank, liquid ammonia evaporation tank, ammonia buffer tank, mixer, ammonia absorption tank, waste water pump, waste water pond, etc. The supply of liquid ammonia is transported by a liquid ammonia tanker. The liquid ammonia is transported from the tanker to the ammonia storage tank using the liquid ammonia discharge compressor, and the pressure in the storage tank is used to transport the liquid ammonia to the liquid ammonia evaporation tank and evaporate into ammonia gas, Control a certain pressure and flow rate through the ammonia buffer tank, then mix it with the dilution air in the mixer evenly, and then send it to the denitrification system. The ammonia gas discharged in emergency from the ammonia system is discharged into the ammonia absorption tank, and discharged into the waste water tank after water absorption, and then sent to the industrial waste water treatment station of the whole plant through the waste water pump.

3. Modification plan
Optimized design scheme of deflector. Remove the baffle plate 2 in the original ammonia injection flue; install a new baffle plate 2 at the position of the original baffle plate 2; install a baffle plate at the divergent section behind the expansion joint at the top of the denitrification flue (center line elevation 49.75 meters)

Design ideas for the transformation of ammonia injection pipeline. The DCS adopts the Ovation control system (version number: Ovation3.5.1) of Emerson Control System Co., Ltd. The original flue gas denitrification system of the unit adopts selective catalytic reduction (SCR) for flue gas denitrification, the absorbent is pure ammonia, and the by-products are nitrogen and nitrogen. water. The denitrification reactor is arranged between the boiler economizer and the air preheater. A graded economizer is installed at the outlet of SCR. The single-side flue ammonia injection grille is divided into 13 zones according to the flue horizontal direction, 4 zones in the depth direction, a total of 52 zones of ammonia injection branch pipes, 18 manual ammonia injection valves, 16 corresponding to 3 zones, 2 One is corresponding to 2 zones, the manual valve of the ammonia injection branch is unbalanced configuration. In this project, through flow field and control optimization, the unit's denitrification system should be able to achieve sub-regional optimization control of the ammonia injection grid. It adopts a large partition + small partition method, and 5 large partitions on one side (set as electric explosion-proof control valves). The small partitions are set according to the flue size, the large partitions are equipped with regulating valves, the small partitions are equipped with manual doors, and the large partition + small partitions work together to achieve precise control of the amount of ammonia injection with different NOx content in the SCR reaction zone, and achieve ammonia injection on demand in different areas. So as to give full play to the performance of the limited volume of the catalyst, under the premise of a small ammonia escape rate, achieve higher denitrification efficiency, suitable for the operation of the boiler under different load
conditions and the use of different coal types, and ensure the stable operation of the boiler denitrification system. The external transformation part of the ammonia injection furnace for denitrification is mainly to dismantle the original ammonia injection pipelines (both sides A/B, 18 branch pipes (DN125) on each side, corresponding to 26 grids), and adopt large partition + small partition after the transformation Method, there are 5 large partitions on one side, and the corresponding relationship with the grille is 6+6+6+6+2. The diameter of the large partition is DN250, the material is stainless steel, the pipeline is equipped with an electric explosion-proof regulating valve, and the electric door is equipped in front Manual door, the installation position is determined according to the site space. Each large partition equipment has 4 small partitions, the diameter of the large partition is DN125, and the material is stainless steel. Each small partition branch pipe is equipped with manual doors. The combined function of the large partition + small partition can realize the precise control of the different NOx content in the SCR reaction zone. In order to realize the on-demand ammonia injection in different areas, and achieve higher denitrification efficiency under the premise of a small ammonia escape rate.

4. Conclusion
The total amount of denitration optimizes the control effect. The NOx concentration at the chimney inlet is controlled at the operating setting target. Under stable load conditions, the NOx concentration at the chimney inlet fluctuates slightly before the transformation, and the maximum value deviates from the set value by 5mg/Nm3; after the transformation, the total input control system is optimized Automatic, the SCR outlet setting value is 19mg/Nm3, the NOx concentration at the chimney inlet fluctuates at 19 ±3mg/Nm3, and the ammonia consumption is relatively stable. Under variable load conditions, the NOx concentration at the inlet of SCR fluctuates greatly before the transformation, and the NOx at the outlet of SCR fluctuates significantly. The NOx concentration at the chimney inlet fluctuates greatly, and the deviation between the measured maximum value and the set value is 8mg/Nm3; after the transformation, the control system is put into operation The total amount is optimized automatically. The amount of ammonia injection is adjusted quickly according to the load and the NOx concentration at the SCR inlet. The NOx concentration at the chimney inlet rises for a short time and then quickly drops, and after a short period of fluctuation, it returns to the set value of 19±5mg/Nm3 for stable operation.

Denitrification zone balanced control effect
After the zone equalization control system was put into operation, the NOx concentration deviation of the five zone measurement points on the A side of the denitration reactor dropped from more than 0% to about 12%, and the B side dropped from about 60% to about 13%.

Coal-fired power plant boilers can optimize the flow field through accurate ammonia injection, balance control, reduce ammonia escape, and solve problems such as air pre-date blockage. After the transformation of precise ammonia injection, the NOx emission of the unit was stably controlled at 40 mg/Nm3; the deviation of the ammonia-nitrogen molar ratio in the front section of the SCR first-layer catalyst was reduced from 11% before the transformation to less than 5%; the ammonia escape was reduced from 7.8×10-6 To 2×10-6; the unit consumption of urea is reduced from 0.61g/(kW·h) to 0.56g/(kW·h); the steady-state deviation value and other indicators are better than the acceptance standard; air preheater Such as equipment blockage is greatly reduced, the power consumption of the induced draft fan is reduced, and the operating safety and economy of the unit are improved.

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