Research and Adjustment of Temperature Deviation on Heating Wall of Front and Rear Wall Opposed Coal-fired Boiler of 1000WM Unit

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Abstract. No.2 boiler is designed by Dongfang boiler group Co., LTD, and is ultra supercritical parameter boiler with variable pressure. In order to alleviate the side wall temperature deviation and to reduce the maximum wall temperature of super-heater, the total air volume alteration test, external secondary air damper alteration test, over-fire air alteration test and the shrinkage adjustment is performed. The test results show that oxygen increase and shrinkage adjustment can improve the deviation of wall temperature and steam temperature. After increasing oxygen, plate super-heater wall temperature deviation reduced by 26 °C, and its outlet steam temperature deviation reduced by 14 °C. After shrinkage adjustment, plate super-heater wall temperature deviation reduced by 34 °C, and the wall temperature difference of final super-heater reduced from 50 °C to 25 °C, the wall temperature of side B plate super-heater reduced by 25 °C.

1. Introduction
There is an extreme deviation regarding the wall temperature on the No. 2 boiler platen superheater and the high temperature superheater, and limited by the wall temperature, the steam temperature is deviated from the design value. This paper aims to alleviate the uneven temperature distribution in the horizontal flue of No. 2 furnace, and reduce the maximum wall temperature of the heating surface of each level under the premise of ensuring the steam parameters as much as possible through the combustion adjustment test[1].

No. 2 boiler is a high-efficiency ultra-supercritical parameter variable-pressure DC furnace manufactured by Dongfang Boiler (Group) Co., Ltd., which adopts single furnace, one intermediate reheating, balanced ventilation, solid air-cooled dry slag, all-steel frame, fully suspended structure Π type boiler, and the boiler type is DG3000/26.15-II1. The pulverizing system applies cold primary air positive pressure direct blowing type, equipped with 6 medium speed roller type coal pulverizers, and two 50% capacity adjustable axial flow primary air fans with movable blades to provide primary hot and cold air conveying pulverized coal. The burner is a swirl burner, which is arranged in three layers of front and rear walls, with 8 burners per layer and a total of 48 burners. The boiler design parameters are shown in Table 1.
Table 1. Boiler design parameters.

| Serial Number | Item                              | Unit | B-MCR Parameters |
|---------------|-----------------------------------|------|------------------|
| 1             | Rated Evaporation                  | t/h  | 3033             |
| 2             | Superheater Outlet Steam Pressure  | MPa  | 26.25            |
| 3             | Superheater Outlet Steam Temperature | °C | 6.5            |
| 4             | Reheat Steam Flow                  | t/h  | 2469.7           |
| 5             | Reheater Inlet Steam Pressure      | MPa  | 5.1             |
| 6             | Reheater Outlet Steam Pressure     | MPa  | 4.9             |
| 7             | Reheater Inlet Steam Temperature   | °C   | 354             |
| 8             | Reheater Outlet Steam Temperature  | °C   | 603             |
| 9             | Water Temperature                  | °C   | 302             |

2. Test Method

The combustion adjustment experiment applies one-factor rotation method, that is, to change one factor (variable) while the other factors remain unchanged, and then gradually change the adjustment contents[2]. Each working condition was stable for 2 hours and tested for 1 hour. The typical load conditions of No. 2 furnace at high load of 950MW~980MW are selected, and its operating parameters and wall temperature are taken as the reference working conditions.

1) The total air volume adjustment test. The total air volume adjustment test is to change the amount of oxygen, that is to change the oxygen control value of the dial to measure the wall temperature and then compare it with the reference working condition value[3].

2) External secondary air test. The amount of secondary air outside the burners was changed to analyze the influence of the amount of external secondary air on wall temperature and steam temperature of the final reheater and the final superheater.

3) Test of changing the burnout air volume. The difference in SOFA airflow means that the aerodynamic field in the furnace is different, and the shift of SOFA airflow changes the center of the flame. This test can measure the carbon content of the ash, the exhaust temperature, the NOx emission, and the temperature of the final superheater tube wall[4], superheated steam, reheat steam temperature, final reheater tube wall temperature, and can determine the best SOFA operation mode by analyzing the impact of different SOFA commissioning combinations on the economy, environmental protection and safety of boilers.

4) Shrinkage adjustment test. By analyzing the distribution trend of wall temperature under various working conditions and comparing with the reference working condition value, the single or partial burner corresponding to the tube with high wall temperature is separately adjusted to reduce local wall temperature[5].

3. Test Results

3.1. Test of Changing the Total Air Volume

From March 29th to April 7th, the test of changing the total air volume was conducted, that is, changing the oxygen volume, and increasing the operating furnace oxygen volume from 2.1% to 2.7%. Two tests were carried out. From the test results, it can be seen that when the furnace oxygen volume is increased from 2.1% to 2.7% at load 950~980MW: (1) The wall temperature deviation on both sides of A and B is changed obviously, changing from 44 °C to 18 °C, reduced by 26 °C. The maximum wall temperature drops a lot on the B side of the platen superheater, which is lowered by 21 °C. (2) The temperature deviation of the steam on both sides of A and B of the outlet of platen superheater is reduced from 24 °C to 10 °C, which is reduced by 14 °C. The deviation from the outlet steam temperature of the high temperature superheater is reduced from 11 °C to 2 °C. The outlet steam
temperature of the high temperature superheater on the B side is increased by 7 °C. (3) The high temperature superheater’s maximum wall temperature was not improved significantly, and the maximum wall temperature on A side of the high temperature superheater is reduced by 5 °C, and the B side was basically unchanged.

3.2. Test of Changing the External Secondary Air

On April 7, a test of changing the external secondary air was conducted. The opening of the external secondary damper of the #3–#6 burners on the front and rear walls was increased from 45% to 55%. Since the opening of the external secondary damper on the #1 and #8 burners has been set at 70%–80%, the opening of the external secondary damper on the #2 and #7 burners has been set at 60%, in order to prevent the fire detection from being unstable, the opening of the external secondary damper of the burners on both sides was not adjusted[6].

It can be seen from the test results that after the external secondary damper on the #3–#6 burner is opened from 45% to 55%: (1) the oxygen content of the furnace is slightly reduced, and the deviation of the oxygen amount on the A and B sides is increased from 0.85% to 1.30%. (2) The wall temperature of the platen superheater shows an overall upward trend. (3) Due to the decrease of oxygen content on B side, the wall temperature of the high temperature superheater increases, especially the B side, the maximum wall temperature on the A side increases by 5 °C, and the maximum wall temperature on the B side increased by 11 °C. Therefore, in the subsequent optimization test and operation, the opening of the external secondary damper of the #3–#6 burner shall not exceed 45%.

3.3. Test of Changing the Over-fire Air Volume

On April 10th, a test of changing the over-fire air volume was carried out, and the over-fire wind damper on the A/B side was reduced from 45% (front wall) / 55% (back wall) to 30% (front wall) / 30% (back wall). It can be seen from the test results that after changing the over-fire air volume: (1) Due to the changing of load, the oxygen content on the A side is increased by 0.45%, and the oxygen content on the B side is decreased by 0.32%; (2) The wall temperature of the high temperature superheater on the A side is significantly lowered, and the maximum wall temperature has dropped by 9 °C. The change of the high temperature superheater’s maximum wall temperature on B side is not obvious, which is reduced by 4 °C. (3) The platen superheater’s wall temperature does not change much; (4) The high temperature reheater’s wall temperature on B side increased slightly by 11 °C.

3.4. Shrinkage Adjustment Test

From March 28th to May 16th, the powder tube shrinkage of B-grinding, C-grinding, D-grinding and E-grinding were adjusted successively. The shrinkage opening before and after the adjustment is shown in Table 2 and Table 3. It can be seen from the test results that after the shrinkage is adjusted: (1) The wall temperature of the platen superheater’s both sides is reduced from 44 °C to 10 °C, which is lowered by 34 °C. The deviation of the platen superheater’s outlet steam temperature is lowered from 24 °C to 19 °C, reduced by 5 °C. (2) The temperature of the platen superheater’s B side is obviously dropped, and the maximum wall temperature is reduced from 594 °C to 569 °C, dropped by 25 °C. (3) The wall temperature of the high temperature superheater is slightly lowered, and A and B sides are reduced by 4 °C and 7 °C respectively. The high temperature superheater’s distribution on the same cross section is more even, and the temperature difference between the maximum and lowest wall temperatures is reduced from 50 °C to 25 °C.

| Table 2. Shrinkage opening before the adjustment. |
|-----------------------------------------------|
| Powder Tube | C-1 | C-2 | C-3 | C-4 | D-1 | D-2 | D-3 | D-4 |
| Opening Degree | 95 | 88 | 90 | 50 | 82 | 92 | 85 | 50 |
| Powder Tube | B-1 | B-2 | B-3 | B-4 | E-1 | E-2 | E-3 | E-4 |
| Opening Degree | 92 | 81 | 90 | 95 | 90 | 93 | 90 | 75 |
Table 3. Shrinkage opening after the adjustment.

| Powder Tube | C-1 | C-2 | C-3 | C-4 | D-1 | D-2 | D-3 | D-4 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Opening Degree | 75  | 88  | 55  | 50  | 70  | 92  | 55  | 50  |
| Powder Tube | B-1 | B-2 | B-3 | B-4 | E-1 | E-2 | E-3 | E-4 |
| Opening Degree | 75  | 81  | 55  | 60  | 75  | 93  | 55  | 60  |

4. Conclusion and Suggestion

(1) When the load is high, the furnace oxygen is increased from 2.1% to 2.7%, which can effectively improve the temperature deviation and steam temperature deviation of the platen superheater. The deviation of the platen superheater’s wall temperature is reduced by 26 °C, and the deviation of the platen superheater’s outlet steam temperature is reduced by 14 °C, and the platen superheater’s wall temperature on B side improved significantly, but the high temperature superheater’s maximum wall temperature did not improve significantly.

(2) After the external secondary air opening degree of the burner #3~#6 is increased from 45% to 55%, the oxygen deviation on both sides of A and B increases, and the platen superheater’s and high temperature superheater’s wall temperature rises, so in the running process, the external secondary damper opening degree of the burner#3~#6 shall be no more than 45%.

(3) It is necessary to cooperate with the means of increasing the oxygen content while reducing the opening degree of the over-fire wind damper at high load, but platen superheater’s wall temperature distribution is not obviously improved.

(4) After the adjustment of the shrinkage, the wall temperature deviation on both sides of the platen superheater and the uniformity of the high temperature superheater’s wall temperature distribution are improved[7]. The wall temperature deviation across the two sides of the platen superheater was reduced by 34 °C. On the same section along the width of the flue, the maximum temperature difference of the high temperature superheater’s wall temperature was reduced from 50 °C to 25 °C. The platen superheater’s maximum wall temperature on B side is reduced by 25 °C. The maximum wall temperature of the high temperature superheater was slightly lowered, and both sides of A and B were lowered by 4 °C and 7 °C.

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