Comparative Analysis on Performance of Tri-sectional and Four-sectional Air Preheater in 1000MW Unit

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Abstract. This paper mainly compares and analyzes the characteristics and performance of air preheater for tri-sectional and four-sectional, it is found that the four-sectional air preheater has a great advantage in economy, this is mainly because the four-sectional air pre-heater has obvious advantages in reducing air leakage rate, it can reduce air leakage of air preheater, reduce power consumption of fan and improve thermal efficiency of unit significantly. In addition, it is found that the deviation range of flue gas temperature distribution of four-sectional air pre-heater is small by measuring the flue gas side temperature of the air preheater, the overall temperature of flue gas side is higher than that of acid dew point, it is more conducive to the prevention of low-temperature corrosion at the cold end of air preheater, and the operation of the unit is more safe.

1. Characteristics of tri-sectional and four-sectional air pre-heater

The tri-sectional air pre-heater is divided into flue gas, primary air and secondary air. The four-sectional air pre-heater is different in structure compared with the tri-sectional air pre-heater, and the other parts of the structure are the same basically. The primary air is arranged in the middle of two secondary air in the four-sectional air pre-heater, this reduces the pressure difference between air sectional, thus reducing the leakage rate of primary air effectively. The schematic diagram of tri-sectional and four-sectional air pre-heater is shown in figure 1.

![Figure 1. The schematic diagram of tri-sectional and four-sectional air pre-heater](image)

2. Performance comparison of tri-sectional and four-sectional air pre-heater

In recent years, with the improvement of energy saving indicators and the enhancement of energy saving awareness in various power plants, four-sectional air pre-heater are more and more favored[1].
New thermal power units built in recent years are basically four-sectional air pre-heater, the million units especially. For example: Huaneng Laiwu million units, Huadian Jurong million units, Huadian Wuhu million units, Huadian Laizhou million units, Guohua Shouguang million units and so on. In addition to the millions of units, four-sectional air pre-heater is also widely used in single-auxiliary units, for example: Datang Linqing 2X350MW units. Taking a power plant as an example, the performance of tri-sectional and four-sectional air pre-heater is compared. Unit #1 of a power plant is 1000MW Ultra supercritical primary reheating unit, boiler outlet steam parameters are 26.15MPa /605℃/603℃. The air preheater is the LAP17286/2600 tri-sectional model manufactured by Dongfang Boiler Factory, the diameter of the rotor is 17286mm and the speed is 0.96r/min. Unit #3 of this power plant is 1000MW ultra-supercritical pressure secondary reheating unit, boiler outlet steam parameters are 33.42MPa /605℃/623℃/623℃. The air preheater is 2-34.5VI (65/50/65)-2900(3000) four-sectional type manufactured by Shanghai Boiler Plant, the diameter of the rotor is 17320mm and the speed is 1.07r/min. The specific equipment parameters of the two units are shown in Table 1 below.

| Parameter                      | Unit          | #1             | #3             |
|-------------------------------|--------------|----------------|----------------|
| Number of the Section         | number       | 3              | 4              |
| Manufacturer                  | /            | Dongfang Boiler| Shanhai Boiler |
| Model                         | /            | LAP17286/2600  | 2-34.5VI(65/50/65) |
| Inner Diameter of the Rotor   | m            | 17.286         | 17.32          |
| Rotate Speed                  | r/min        | 0.96           | 1.07           |
| Height of Hot Section         | mm           | 1200           | 1750           |
| Height of Cool Section        | mm           | 1050           | 1150           |
| Material of Hot Section       | /            | Q215AF         | Q215AF         |
| Material of Cool Section      | /            | Enamel         | Enamel         |

Unit #1 air preheater is tri-sectional air pre-heater, unit #3 air preheater is four-sectional air pre-heater. The air preheater of the two units has the same dimensions. The size of two air preheater is basically the same, the speed is the same and the sealing mechanism is the same, the total heat transfer area of furnace #3 air preheater is slightly larger. The performance parameters of the two air preheaters are shown in Table 2.

| Parameter                          | Unit          | #1             | #3             |
|------------------------------------|--------------|----------------|----------------|
| Inlet Temperature of Primary Air   | ºC           | 26             | 27             |
| Outlet Temperature of Primary Air  | ºC           | 333            | 356            |
| Inlet Temperature of Secondary Air | ºC           | 20             | 23             |
| Outlet Temperature of Secondary Air| ºC           | 341            | 354            |
| Inlet Temperature of Flue Gas      | ºC           | 376            | 375            |
| Outlet Temperature of Flue Gas     | ºC           | 117            | 116            |
| Primary Air Flow of Air Pre-Heater Inlet | t/h       | 736.5          | 652.2          |
| Secondary Air Flow of Air Pre-Heater Inlet | t/h       | 2691.9         | 2322.1         |
| Flue Gas Flow of Air Pre-Heater Inlet | t/h       | 3815.6         | 3439.8         |
| Primary Air Flow of Air Pre-Heater Outlet | t/h      | 584.5          | 537.0          |
| Secondary Air Flow of Air Pre-Heater Outlet | t/h      | 2632.0         | 2298.8         |
| Flue Gas Flow of Air Pre-Heater Outlet | t/h       | 4027.5         | 3578.4         |
| Air Leakage of Primary Air         | t/h          | 152            | 115.2          |
| Air Leakage of Secondary Air       | t/h          | 59.9           | 138.6          |
| Total Air Leakage                  | t/h          | 211.9          | 138.6          |
| Air Leakage Rate of Air Pre-Heater | %            | 5.55           | 4.03           |
| Air Leakage Rate of Primary Air    | %            | 20.5           | 17.7           |
| Parameter                  | Unit | #1   | #3   |
|---------------------------|------|------|------|
| Side of Flue Gas Resistance | Pa   | 1158 | 1100 |
| Side of Primary Air Resistance | Pa   | 550  | 600  |
| Side of Secondary Air Resistance | Pa   | 880  | 1110 |

Table 2 shows the main economic operation aspects of the tri-sectional and four-sectional air pre-heater. The air leakage rate of tri-sectional air pre-heater is about 5.5%, and that of four-sectional air pre-heater is only about 4%. This is mainly because the four-sectional air pre-heater places the primary air side with the maximum pressure between the two secondary air sides, the two secondary air sides with lower pressure are adjacent to the flue gas side with negative pressure. Air leak from the secondary side to the flue gas side with negative pressure, and air leak from the primary air side to the secondary side because of the pressure difference between the flue gas side and the air side is reduced compared with the tri-sectional air pre-heater, thus reducing the air leakage rate on the whole. The principle of four-sectional air pre-heater to reduce air leakage is shown in Figure 2.

![Diagram of medium flow in the tri-sectional and four-sectional air pre-heater](image_url)

Figure 2. Diagram of medium flow in the tri-sectional and four-sectional air pre-heater

3. Economic comparison of the tri-sectional and four-sectional air pre-heater

At present, air preheater is widely used as auxiliary boiler equipment for large and medium-sized power station boilers in China, the air preheater has the advantages of high heat transfer surface density, compact structure, less steel consumption and easy layout compared with the tubular air preheater. However, the high air leakage rate of air pre-heater is a very difficult problem, which is the fatal defect of this kind of equipment and seriously affects the safety and economy of boiler unit[2]. To make the unit in the best economic operation state, reduce the air leakage of air preheater is the need for many power plants to strive for a first-class enterprise and improve economic benefits of enterprises. The air leakage rate is reduced, so that the power consumption of induced draft fan, primary fan and blower fan is reduced. It is estimated that every 1% reduction in air leakage rate of an air preheater of a 300 MW unit will save 1.2 million per year[3]. Therefore, the four-sectional air pre-heater has obvious advantages in reducing air leakage rate of air pre-heater, which can significantly reduce air leakage rate of air preheater, and the power consumption of the three big fans is relatively low.

4. Operation safety comparison of the tri-sectional and four-sectional air pre-heater:

The Junker air preheater is a heat exchanger which operates in reverse flow mode. The rotor rotates at a certain speed, passing through the flue gas side and the air side in turn, the cycle goes round and round to realize the heat exchange between flue gas and air. There is a gradient distribution of flue gas temperature through the heat exchanger surface of the air preheater, and this non-uniformity is more severe under the influence of factors such as the size of the air preheater and air leakage. The larger the rotor size of air preheater, the greater the smoke temperature deviation[4]. As a heat exchanger of the tail flue, the air preheater generally works in a temperature environment of 100°C~160°C and often encounters low temperature condensation, which causes corrosion of the cold end. An important factor causing low temperature corrosion of air preheater is the temperature level and distribution of flue gas
side, the smaller the deviation range of flue gas temperature distribution, the higher the overall smoke temperature, the more conducive to avoid the occurrence of low-temperature corrosion.

Figure 3. Measuring point number position

In order to study the flue gas temperature characteristics of the tri-sectional and four-sectional air pre-heater, the flue gas side temperature of unit #1 and unit #3 A and B air preheater was measured respectively under full load condition, so the temperature distribution can be measured. Test instruments: temperature inspection instrument, thermocouple. The A and B air preprocessor measures 15 points from left to right, the measuring point number position is shown in Figure 3, the number 1 to 15 is the A air preheater from left to right of the furnace, and the number 16 to 30 is the B air preheater from left to right of the furnace. Each measuring point was set to record smoke temperature for 10 minutes, and the test lasted for 2 hours in total, each measuring point recorded 12 groups of values, and the last 12 groups were averaged, and the final temperature measurement results were shown in Figure 4.

Figure 4. Results of temperature test

As can be seen from Figure 4, the flue gas temperature distribution deviation of the tri-sectional air pre-heater (#1) is above 35°C, while the flue gas temperature distribution deviation range of the four-sectional air pre-heater (#3) is reduced to about 25°C. The overall temperature of flue gas side of the four-sectional air pre-heater is higher compared with the tri-sectional air pre-heater, and higher than the acid dew point temperature, it is more conducive to the prevention of low-temperature corrosion at the cold end of the air preheater. So the operation of the unit with four-sectional air pre-heater is more safe[5].

5. Conclusions
In this paper, the air preheater for tri-sectional and four-sectional is introduced, the parameters and performance of air preheater in tri-sectional and four-sectional are compared and analyzed, it is found that the four-sectional air pre-heater has obvious advantages in reducing air leakage rate of air preheater, it can reduce air leakage of air preheater, reduce power consumption of fan and improve thermal efficiency of unit significantly. In addition, it is found that the deviation range of flue gas temperature distribution of four-sectional air pre-heater is small by measuring the flue gas side temperature of the air preheater, the overall temperature of flue gas side is higher than that of acid dew point it is more conducive to the prevention of low-temperature corrosion at the cold end of air preheater, and the operation of the unit is more safe.
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