Characteristics and Typical Problems Analysis of Laizhou 1000MW Double Reheat Tower Boiler

Chunxing Xu
Huadian Electric Power Research Institute Co., Ltd, Shandong Branch, Jinan 250014, China
Corresponding author’s e-mail: xu1566268@163.com

Abstract. The boilers of no. 3 and no. 4 units of laizhou power plant phase II project are 1000MW ultra-supercritical pressure double reheat tower boilers. The units 3 and 4 have been puted into operation in august and november 2019 respectively, and several typical problems of tower boiler are encountered during boiler commissioning. This paper mainly introduces the characteristics of the boiler and some typical problems and their solutions encountered during commissioning.

1. Introduction of the boiler
The boiler of laizhou power plant phase II project is a 1000MW ultra supercritical pressure double reheat tower boiler, operating spiral coil boiler with variable pressure, single furnace tower layout, secondary reheat, tangential corner firing, balanced draft, dry ash extraction, all steel suspended structure, semi-open arrangement[1].

1.1. Boiler performance parameter

| Section                        | Unit | BMCR  | BRL  | THA  |
|--------------------------------|------|-------|------|------|
| Flow of Superheated steam      | t/h  | 2717  | 2638 | 2557 |
| Outlet pressure of Superheated steam | MPa  | 33.42 | 32.52 | 31.62 |
| Outlet temperature of Superheated steam | ºC  | 605   | 605  | 605  |
| Flow of Reheat steam           | t/h  | 2410  | 2340 | 2277 |
| Inlet pressure of reheat steam  | MPa  | 10.99 | 10.67| 10.40 |
| Temperature of reheat steam    | ºC  | 423   | 423  | 424  |
| Reheat steam outlet pressure   | MPa  | 10.77 | 10.45| 10.19 |
| Outlet temperature of Reheat steam | ºC  | 623   | 623  | 623  |
| Flow of Secondary reheat steam | t/h  | 2069  | 2006 | 1961 |
| Inlet pressure of secondary reheat steam | MPa  | 3.48  | 3.37 | 3.30 |
| Inlet temperature of secondary reheat steam | ºC  | 444   | 444  | 445  |
| Outlet pressure of secondary reheat Steam | MPa | 3.23  | 3.12 | 3.06 |
| Outlet temperature of secondary reheat Steam | ºC  | 623   | 623  | 623  |
| Feed-water temperature         | ºC  | 328   | 326  | 324  |
| Economizer inlet pressure      | MPa  | 37.42 | 36.29| 35.17 |
### Section Unit BMCR BRL THA

| Section                         | Unit | BMCR | BRL | THA |
|--------------------------------|------|------|-----|-----|
| Consumption of fuel            | t/h  | 395.5| 385.9|     |
| Guaranteed thermal efficiency  | %    | /    | 95.1|     |

1.2. **Description of boiler**
In the upper part of the boiler, along the direction of flue gas flow, there are low temperature super-heater, high temperature re-heater low temperature section, high temperature super-heater, high temperature re-heater high temperature section, low temperature re-heater, coal economizer. The heating surface in the upper part of the boiler is arranged horizontally, and the structure through the wall is completely sealed in metal[2]. The overall arrangement of the boiler is shown in figure 1.

![Figure 1. The overall arrangement of the boiler.](image)

2. **Introduction of each system**

2.1. **Steam water system**

2.1.1. **Economizer**
Economizer is divided into graded economizer and main economizer, and the graded economizer is located between the outlet of SCR and the inlet of air pre-heater, divide the left and right flue into two halves. The heating surface of the main economizer is located above the boiler, and the main economizer arranged in the front and rear flue in parallel respectively.

2.1.2. **Superheated steam system**
Super-heater is divided into low temperature super-heater and high temperature super-heater, the low temperature super-heater is arranged in front of the furnace outlet, the high temperature super-heater is arranged between the cold and hot sections of the high temperature re-heater, absorbs the radiant heat in the furnace mainly. The low temperature super-heater and high temperature super-heater are arranged along the current.

2.1.3. **Reheat steam system**
Reheat steam system divided into reheat low temperature re-heater and reheat high temperature re-heater, low temperature re-heater arrangement before the upper chamber of a stove or furnace flue, high temperature re-heater cold section arranged between low temperature super-heater and high temperature super-heater, high temperature re-heater hot section arranged between high temperature
super-heater and low temperature re-heater. The low temperature re-heater is arranged between the high temperature re-heater and the economizer.

2.1.4. Double reheat steam system

Double reheat steam system divided into double reheat low temperature re-heater and double reheat high temperature re-heater, the low temperature re-heater is arranged in the upper rear flue of the furnace, the cold section of the high temperature re-heater is arranged between the low temperature super-heater and the high temperature super-heater, the hot section of the high temperature re-heater is arranged between the high temperature super-heater and the low temperature re-heater. The low temperature re-heater is arranged between the high temperature re-heater and the economizer.

2.2. Combustion equipment

The main components of the combustion system are: grouped burner bellows, toothed pulverized coal nozzle, auxiliary air nozzle with preset horizontal deflection angle, BAGP and UAGP. The actual picture of the burner is shown in figure 2.

![Figure 2. The actual picture of the burner.](image)

The main bellows are provided with 12-layer toothed pulverized coal nozzles, perimeter winds are arranged around pulverized coal nozzles. The burner bellows are divided into 5 separate groups, the next three groups are the main burner bellows, each bellows has 4 layers of pulverized coal nozzles, corresponding to 2 coal mill. Each coal mill corresponds to adjacent 2 layers of pulverized coal nozzles, with 1 layer of auxiliary air nozzles arranged between them. A combination nozzle is arranged above the pulverized coal nozzle, auxiliary air nozzles and direct air nozzles with preset horizontal deflection Angle each account for about 50% of the outlet flow area. The nozzles can swing up and down, of which the pulverized coal nozzles can swing up and down range of ±20°, the secondary air nozzles can swing up and down range of ±30°.

Two stage exhaust air burners are arranged above the main bellows, the burners can be divided into BAGP and UAGP, the exhaust air in the two groups was arranged in four layers, with a total of eight layers of exhaust air nozzles. The exhaust air nozzle can swing up and down and left and right, the fluctuation range is ±30°, the horizontal swing range is ±25°.

3. Steam temperature regulation

3.1. Superheated steam regulation

The superheated steam temperature is regulated by coal water ratio and attemperation water. There are two levels of attemperation water, the first stage is arranged in the low temperature super-heater inlet pipe and the second stage is arranged on the connecting pipe between the low temperature super-heater
and the high temperature super-heater.

3.2. Reheat steam regulation
The main ways of reheating steam temperature regulation are burner swing regulation and increasing excess air coefficient under low load, flue gas baffle regulation as a means of balance, under accident or emergency conditions to consider the water temperature reduction. The heat absorption ratio of the first and second re-heater is basically 58:42 under each load, and it decreases slightly under low load.

4. Problems encountered during the commissioning
4.1. Economizer and economizer outlet pipeline vibration
There exists the vibration phenomenon of header pipe under the outlet of economizer and economizer to water wall when the boiler is hot. The reason is that the main economizer of the boiler is located at the top of the furnace, and the economizer is easy to vaporize after the boiler stopped burning and the water is stopped. The superheat water enters the economizer for vaporization when the boiler is hot, resulting in vibration. Solution: reduce the water supply as far as possible when the boiler is hot, and maintain the water supply at 50t/h~100t/h. In addition, the outlet temperature of the economizer is closely monitored. After the superheat of the outlet of the economizer is reduced, the amount of water is increased to prevent water hammer and pipeline vibration. In addition, the BCP should be opened as soon as possible after boiler water is finished, this helps to accelerate the circulation of water in the furnace, accelerate the uniformity of heating, so as to reduce vibration.

4.2. Economizer vaporization
During the start-up of the whole unit, vaporization of economizer occurs when the unit is under low load, as follows: The rate of temperature rise of economizer on the side of the primary re-heater and the secondary re-heater is inconsistent. The water temperature of economizer on the side of the secondary re-heater increases significantly faster than economizer on the side of the primary re-heater, the temperature difference between the two is as much as 50℃. Combined with the saturation temperature, it can be seen that the economizer on the side of the secondary re-heater has been vaporized seriously[3].

The analysis shows that the setting of flue separation wall results in different thermal environment of front and rear economizer, the flue gas used to heat the economizer on the side of the secondary re-heater has a higher flow rate and higher temperature, and more intense heat exchange must occur with the economizer on the side of the secondary re-heater. In addition, under the BMCR, the boiler's feed water temperature is 328℃ and the pressure is 37.42MPa, higher feed water temperature is also one part of the reason that the economizer outlet is prone to vaporization[4]. In addition, the operators in the low-load phase usually maintain a large air volume, resulting in more fuel into the furnace, the amount of smoke produced is large, pulverized coal in the furnace combustion time is prolonged, the boiler heating up and pressure boost rate is also large[5]. At this time, the boiler evaporation is small, the water flow rate in the economizer is slow, the economizer is easy to absorb more heat.

Solutions: combustion adjustment timely, reduce the total air volume appropriately, control the rate of boiler heating up and pressure raising during start-up; Increase the water supply flow to ensure that the economizer can get more water. Reduce the water supply temperature at the initial start-up stage to ensure that the inlet water of economizer has a large owe enthalpy. Monitor the water temperature of the economizer outlet closely and control the temperature at least 30℃ greater than the saturation temperature value.

4.3. The temperature of reheat steam is low
During the start-up of the whole unit, the temperature of reheat steam is low, the load below 800MW is lower than the design value in particular, more than 30℃, the reheat steam temperature can only reach about 610℃ when the unit is full load. The load is lower the deviation is greater, as a result, the
efficiency of the unit is reduced, and the design value cannot be reached, the superiority of secondary reheat unit is not reflected.

It is found that the exhaust temperature of ultra-high pressure cylinder and high-pressure cylinder of steam turbine is about 5~10℃ lower than the designed value on average. Therefore, the steam temperature entering the boiler re-heater is low and deviates from the design value, resulting the temperature of reheat steam is low[6]. In addition, the design of super-heater and re-heater heating surface has some deviation, causes the super-heater placed in the front to absorb too much heat, lead to the flue gas entering the re-heater heating surface temperature is low[7]. Therefore, the heat absorption of re-heater is insufficient, and the temperature of reheat outlet steam is lower than the designed value.

Solutions: adjust the flame center of the boiler, raise the height of flame center in furnace and raise the temperature of reheat steam through the secondary air distribution, the distribution of the upper and lower coal grinding amount, the operation mode of the mill, the outlet temperature of the mill, the primary wind speed of the mill, the coal powder fineness, the Angle of the burner nozzle and other means, through the secondary air distribution, the distribution of the upper and lower coal grinding amount, the operation mode of the mill, the outlet temperature of the mill, the primary wind speed of the mill, the coal powder fineness, the Angle of the burner nozzle and other means. When the load is low, increase the amount of smoke by increasing the air supply to increase the excess air coefficient and improve the convective heat transfer effect.

5. Conclusions
In this paper, several typical problems encountered in the commissioning of 1000MW reheat tower boiler in laizhou power plant phase II project are analyzed. It is found that the reheat steam temperature of the unit is low, the reheat steam temperature cannot reach the design value, and the superiority of the secondary reheat unit cannot be reflected. The analysis shows that the main problems should be focused on the optimum design of steam turbine recovery system and boiler re heater heating area. Finally, some suggestions are put forward from the perspective of design and operation.

References
[1] Gao, H.T. (2014) Development of ultra supercritical unit with double reheat cycle. Boiler Technology, 45(4): 1-3.
[2] Yao, D.H., Zhu, Y.F. (2017) Design Characteristics of 1000MW Double Reheat Ultra-Supercritical Tower Boiler. Boier Technology, 48: 01-06.
[3] Feng, W.Z. (2006) Commission adjustment and Operation of a 900 MW Tower Type Super-critical Boiler. Boiler Journal of Power Engineering, 02: 167-170.
[4] Zhao, Z.D. (2015) Double reheat ultra-supercritical unit reheat steam temperature control. Thermal Power Generation, 44: 113-118.
[5] Wang, H.J. (2017) Thermal economics analysis for double reheat units. Thermal Power Generation, 46(1): 7-10.
[6] Gu, Y.X. (2013) Thermal economic analysis on an ultra supercritical unit with second reheat cycle. Thermal Power Generation, 42(9): 7-9.
[7] Cai, B.L. (2016) Dynamic process characteristic anlysis and control strategy verification on double reheat ultra-supercritical coal-fired power units. Proceedings of the CSEE, 36(19): 5288-5299.