The Analysis and Solutions for 1025t/h Boiler Water Wall Coking

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Abstract. After the renovation of the low NO\textsubscript{x} combustion, furnace combustion environment has been changed, reducing atmosphere of the furnace is enhanced that made coal ash fusion point temperature reduced. At the same time by the impact of the changing of the aerodynamic field in furnace, some boiler’s water-coll wall get serious coking phenomenon. This paper takes a 1025t/h tangentially fired boiler as an example, takes an analysis of its coking phenomenon, and puts forward the corresponding solutions.

Introduction

The coal-fired boiler is design and manufactured by Shanghai Boiler Factory Co., Ltd, with the technology introduced from American Engineering Company (CE). The boiler is a subcritical pressure single reheat controlled circulation boilers, and the model is SG-1025/17.50-M885, furnace width is 14022mm, depth is 12615mm, design burning high volatile bituminous coal. The boiler are equipped with double-inlet and double-outlet ball mill positive pressured direct-fired pulverizing system, three coal mills take six layers primary air nozzles. The combustion mode is tangentially firing.

Figure 1. Diagram of coke block.
The boiler has serious coke situation, the coke area is focus on the water-cool wall that between the second floor burner to the top burner’s fire and fire back side. The state of the coke is hard and dense, and shows azure stone shape (Fig. 1). During the operation, the coke on the water-cool wall presents fluid state.

**Coking Mechanism and Harm**

By the impact of the high temperature of the furnace, the state of the ash after the combustion usually present melted or partially melted. When the melted or partially melted ash adheres to the water-cool wall, there will form a layer of dense ash, coke formed. Coke increases the heat transfer resistance of the water-cool wall and deteriorates the heat transfer performance, the temperature of the furnace flue gas and the coke surface is increased. At the same time, by the effect of the coke surface’s rough surface structure, ash adhesion phenomenon aggravated, the amount of the coke get increased. When the coke block reaches a certain size, by the effect of its self weight and furnace load variation, the coke will get off the water-cool wall, coke falling phenomenon happened [1-4].

Coke has serious influences on the boiler’s safety and economic operation. By the impact of the coke, the heat absorption of the water-cool wall is reduced. In order to keep the boiler output, more coal should be burned. The reduction of the heat absorption results in the furnace exit gas temperature to rise, which will lead superheater and reheater’s tube over temperature, even tube explosion. The coke will also cause the quantity of the desuperheating water increase, which gets influences on economic operation. The coke falling has serious effect on boiler’s safety operation. When the dense coke falling down, the water-cool wall of cold ash bucket could be easily be smashed. The falling of large coke block has great impact on the furnace aerodynamic field, which could cause boiler flameout. In the case of hydraulic slag removal, large coke blocks falling into the slag ship and produces a large amount of water vapor, which resulting in furnace pressure fluctuations and cause the boil to stall.

**Coking Analysis**

The cause of the boiler coking phenomenon can be summarized from two aspects, internal and external factors. The internal factors can be attributed as coal quality, external factors are mainly as the wind, the following will give an analysis from these two aspects.

**Low Ash Fusion Point**

Due to the coal quality, the coal ash fusion point is in a low state that between 1100~1250°C. During the operation, the temperature of the furnace is around 1350°C, which is much higher than the ash fusion point. High furnace temperature and low ash fusion point made water-cool wall coking easily happened. When the ash adheres to the water-cool wall, the temperature is still over its fusion point, which the melted or partially melted ash condenses to coke. At the same time, after the renovation of low NOx combustion, the excess air coefficient of the furnace is reduced that cause the main combustion zone under oxygen deficient, which produce a reducing atmosphere. Under the reducing atmosphere, Fe2O3 were reduced to FeO, FeO react with SiO2 and Al etc. form to eutectic, which deeply decreases the ash fusion point about 150~200°C. Low ash fusion point exacerbates the coking phenomenon.
High R90

Through checking the fineness test of pulverized coal, the R90 of the coal is between 30%~40%, which is much higher than the request of “DL/T 831-2015 Guide on selection of furnace characteristic parameters for large pulverized coal fired power boilers”. Calculate under the guide, the R90 takes 23% is appropriate, which is lower about 7%~17% than actual fineness. During the combustion process, big size coal will be easily left to the water-cool wall and form the coking phenomenon. Big size coal need more time for burning, when it were left to water-cool wall that it will continue burning on the water-cool wall, which will increase the coking phenomenon.

Large Tangential Circle Diameter

Through the review of the furnace cold state aerodynamic field test reports, it found that the A2 layer primary wind tangential circle long axis diameter is about 9.8m and short axis diameter is about 9.2m, which is a big tangential circle size for the furnace size of 14.022*12.615m. At the same time, checking the A2 layer primary wind distribution map, there has a certain velocity closing-to-wall wind. Big tangential circle will make coal easier flush the water wall, during the combustion the big size coal will be thrown to the water wall by the rotating flow and formed coke.

Unbalance of The Primary Wind Velocity

By checking the furnace’s DCS operation data, the velocity of the primary wind exist bigger deviation. For instance, April 12, under the load of 74.13MW, the velocity and deviation of the primary wind is shown in Table 1 and Fig. 2.

Table 1. The velocity and deviation of the primary wind.

<table>
<thead>
<tr>
<th>Layer</th>
<th>#1 Velocity</th>
<th>Deviation</th>
<th>#2 Velocity</th>
<th>Deviation</th>
<th>#3 Velocity</th>
<th>Deviation</th>
<th>#4 Velocity</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>27.83m/s</td>
<td>12.83%</td>
<td>24.85m/s</td>
<td>0.75%</td>
<td>22.12m/s</td>
<td>-10.32%</td>
<td>23.86m/s</td>
<td>-3.26%</td>
</tr>
<tr>
<td>A2</td>
<td>35.00m/s</td>
<td>5.92%</td>
<td>34.33m/s</td>
<td>3.89%</td>
<td>35.04m/s</td>
<td>6.04%</td>
<td>27.81m/s</td>
<td>-15.84%</td>
</tr>
<tr>
<td>C1</td>
<td>36.95m/s</td>
<td>23.8%</td>
<td>27.27m/s</td>
<td>-8.64%</td>
<td>30.06m/s</td>
<td>0.71%</td>
<td>25.11m/s</td>
<td>-15.87%</td>
</tr>
<tr>
<td>C2</td>
<td>25.32m/s</td>
<td>-7.31%</td>
<td>31.27m/s</td>
<td>14.47%</td>
<td>28.58m/s</td>
<td>4.62%</td>
<td>24.10m/s</td>
<td>-11.78%</td>
</tr>
</tbody>
</table>
Figure 2. Contrast diagram of Primary wind velocity.

From the table 1 and Fig. 2, we can see that every layer’s primary wind velocity is unbalance, the biggest velocity deviation of A1 layer is 12.8%, A2 layer is 15.8%, C1 layer is 23.6% and C2 layer is 14.5%. Most of the deviation is much bigger than 5%, which is permissible upper limit of the velocity deviation. High primary wind velocity deviation has direct influences on the furnace tangential circle, which caused the deviation of the tangential circle and the increasing of the closing-to-wall wind, make water wall coking happened.

Suggestions

According to the situation of this 1025t/h boiler, suggestions were given from operation and maintenance to reduce the coking phenomenon:

1. Strict control the coal quality, as far as possible to use the high ash fusion point coal;
2. Adjust and optimize the coal-pulverizing system, control the fineness of pulverized coal in the qualified range, or take the technical transformation for the coal-pulverizing system to meet the requirements;
3. If the coal quality cannot be changed, try stratified combustion mode, fire the low ash fusion point coal in bottom layer, and the upper layer fire the high ash fusion point coal;
4. Change the arrangement of the secondary wind from uniformity distribution to drum distribution, which could reduce the temperature of the furnace;
5. Increase the surrounding wind to enhance the rigidity of the primary wind;
6. Check the leaking of the flue system and combustion area, avoid the low wind speed that cause by the gap;
7. Make the corresponding oxygen control scheme, raise the running oxygen to reduce the reducing atmosphere that under the premise of meeting the requirement of NOx emission;
8. Reduce the tangential circle diameter to avoid the coal flush the water wall;
9. Balance the velocity of the primary wind, keep the tangential circle away from the deflection;
10. Measure the speed of the secondary wind, check whether the secondary wind speed is low that cannot wrap the primary wind.

**Conclusion**

After the renovation of low NO\textsubscript{x} combustion, furnace combustion environment has been changed, coking phenomenon becomes one of the most serious problems. Every power plant should enhance the treatment of the coking problem and improve the safety and economic operation.

**References**


