The Influence of the Boiler Bottom Air Leakage for Corner Tangential Firing Boiler

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Abstract. Based on a corner tangential boiler in a power plant, Temperature field, flow field, velocity field and other factors in furnace is simulated with FLUENT software at different boiler bottom air leakage ratio. These study results provides a further evidence for high efficient and safe operation of boilers.

Introduction

Energy is the foundation of the survival and development of human society. The coal-fired thermal power plant consumes much energy and discharges contaminations quite a lot, which becomes the keystone of the energy conservation. The flue gas loss makes up the largest proportion (60%-70%) in heat loss. Taking an power unit as the example, to increase 10°C for the exhaust gas temperature will lead to 0.5~0.8% additional waste heat loss and 1.0 g/kW•h additional coal consumption. Air leakage is the most important reasons of the exhaust gas temperature rise. Air leakage include air leakage of furnace, air leakage of boiler bottom, air leakage of coal pulverizing system and air leakage of flue. Among them, the impact of air leakage of boiler bottom is the largest. Boiler bottom air leakage is unavoidable for dry-type slag extractor, but the air leakage quantity is small and poses no threat to the safety and economy of the boiler. There are different views on the influence of the boiler bottom air leakage for dry-type slag system. Wet-type slag extraction has a better leak proofness, However, when slagging , coke dropping or equipment fault exist, the water block is damaged and cold air flow into furnace quickly .It leads to burning center moves upward, gas temperature increase, boiler efficiency decrease, even boiler fire extinguishing. Some problems about the influence of the boiler bottom air leakage for corner tangential firing boiler still exist and need some specific regulations. Temperature field, flow field, velocity field and other factors in furnace is simulated with FLUENT software at different boiler bottom air leakage ratio. The study has the important theory significance reference role.

The Numerical Modeling

The study mainly focus on a 300MWcorner tangential boiler in a power plant, There are six layers burners. Established a three-dimensional model according to the actual geometry. The software FLUENT has been used in this paper, and the numerical modeling is shown in Figure 1[1].
Results and Discussions

Change of Temperature

In order to ensure the same excess air ratio, the increase of bottom air leakage is equal to the reduction of second air. The models of different bottom air leakage (0%, 0.2%, 0.5%, 1.0%, 1.5%, 2.0%, 3.0%, 5.0%, 7.0%, 10.0%) are built, temperature distributions cross-section of burners is are shown in Figure 2.
With the bottom air leakage increase from 0% to 1.0%, burning center does not move and high temperature zones near the burner increase. The influence of bottom air leakage to cold ash hopper zone increases along with the increase of bottom air leakage, the burning center moves upward. The temperature of cold ash hopper zone decrease and high temperature zones near the burner increase. The changing curves of temperature are shown in Figure 3. With the bottom air leakage increase from 0% to 1.0%, average temperature and maximum temperature in furnace almost have no change, the outlet temperature of furnace has a small risen about 3.5°C. When the bottom air leakage increases to 10%, average temperature declines by 33°C and the outlet temperature of furnace has risen about 36.3°C, but maximum temperature in furnace is almost a constant.

**The Change of Flow Field**

The velocity distributions on cross-section of burners are shown in Figure 4 and flow field distributions are shown in Figure 5. With the increase of bottom air leakage, the velocity around burners decrease, and the velocity from over fire air nozzles to furnace outlet increase. When the bottom air leakage is less than 1.5%, the reflux speed at the bottom of cold ash hopper increase. With the continuing increase of bottom air leakage, the reflux speed is starting to decrease. When the bottom air leakage is more than 1.5%, the velocity on the top of furnace is higher and a reflux is formed in there.
Figure 4. Velocity distribution on cross-section of burners.
The track of pulverized coal particles comes from the lowest burners are shown in Fig.6. When the bottom air leakage is less than 0.5%, the pace times of pulverized coal particles comes from the lowest burners are longer. When the bottom air leakage is more than 0.5%, the rotating momentum of pulverized coal particles decrease and the pace times also decrease. Perhaps you want to send a system administrator an alert. When the bottom air leakage reaches 10%, many of unburnt pulverized coal particles had left burning zone. The burning-out degree of pulverized coal particles is unsatisfactory.
The Change of CO Concentration

The concentration distributions on cross-section of burners are shown in Fig.7. The primary air carries pulverized coal particles into furnace, incomplete combustion occur and CO concentration increase because of the low O\textsubscript{2} concentration. With the increase of bottom air leakage, O\textsubscript{2} concentration increase and CO concentration gradually decrease. This is due to the air leakage offers a more beneficial combusting environment at bottom furnace. Due to reduction of furnace temperature and second air, CO concentration from upper layer burners to outlet of furnace increase as the increase of bottom air leakage.

The pulverized coal particles released volatile matter and burned after they got into furnace. In order to ensure the same excess air ratio, the increase of bottom air leakage is equal to the reduction of second air. So the flow velocity around burners decrease. When bottom air leakage is less, some O\textsubscript{2} is offered for the burning of pulverized coal particles. With the increase of bottom air leakage, CO concentration gradually decrease and the heat from the burning increase. The temperature of cold ash hopper doesn't decrease as the increase of bottom air leakage. The pace times of pulverized coal particles is longer and the reflux speed is higher. With the continues to increase of bottom air leakage, the pulverized coal particles in cold ash hopper is few and the heat from the burning is limited though more O2 is offered. A lot of bottom air leakage takes a lot to drop cold ash hopper temperature down, incomplete combustion occur. Besides, bottom air leakage get into furnace, thus form a upward moment. It leads to burning center moves upward, gas temperature increase, the velocity on the top of furnace is increase and incomplete combustion occur in there. Moreover, bottom air leakage get to the high temperature zoon, the volume will expand 4-9 times. Under the condition that fission cross area remain about the same, the upward velocity will increase sharply, and upward moment will increase sharply too. But the rotating momentum will decrease the pace times of pulverized coal particles will decrease due to the conservation of momentum, incomplete combustion occur, carbon content of fly ash, mechanical loss and incomplete combustion loss increase.

Ash deposition and slagging caused by the upward velocity increase sharply and the reflux form will seriously threaten the security of the boiler.
Conclusions

The study bases the same excess air ratio, using FLUENT software to simulate the influence of the boiler bottom air leakage for corner tangential firing boiler. The conclusion follows:

1) With the bottom air leakage increase, high temperature zones near the burner increase.

2) With the bottom air leakage increase from 0% to 1.0%, the influence is very small. With the bottom air leakage increase from 1.0% to 2.0%, average temperature decrease, the outlet temperature of furnace has risen about 36.3°C, but maximum temperature in furnace is almost a constant.

3) When bottom air leakage is less, some O2 is offered for the burning of pulverized coal particles, CO concentration gradually decrease and the pace times of pulverized coal particles is longer. The less bottom air leakage plays a positive role in boiler furnace combustion.

4) A lot of bottom air leakage takes a lot to drop cold ash hopper temperature down, incomplete combustion occur. A upward moment is caused by the bottom air leakage get into furnace. It leads to burning center moves upward, the pace times of pulverized coal particles decrease. Moreover, bottom air leakage get to the high temperature zoon, the volume will expand 4-9 times, the upward moment increase, spinning momentum, and incomplete combustion loss increase.

5) Ash deposition and slagging caused by the upward velocity increase sharply and the reflux form will seriously threaten the security of the boiler.

In conclusion, the less bottom air leakage plays a positive role in boiler furnace combustion, but a lot of bottom air leakage plays a negative role in boiler furnace combustion and should be avoided.

References