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On the Controlled-spin Intensity Method For the Tangentially-fired Furnaces

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Abstract

This paper put forward the controlled spin intensity method for the tangentially-fired furnaces to solve the problems existed in the counter-tangential operation. The numerical simulation was used in this paper to discuss some basic principles.

Keywords: *controlled spin, residual whirl, to start whirl, to depress whirl, angular momentum flux*

1. General

There is often residual whirl at the furnace outlet of the tangentially-fired furnaces. It has serious influence on the safe operation of the boiler. It is well known that the large temperature imbalance of the flue gas and steam can be a serious threat to the safe operation of the superheater and the reheater. In the counter-tangential operation, some counter-tangential air-streams are used to depress residual whirl intensity. However, there are some misunderstanding in counter-tangential operation, which does not take account of the particularities of the tangential firing. It only eliminate whirl by itself. The controlled whirl method is put forward in this paper, which not only keep the advantage of the corner tangential firing, but also effectively controls the residual spin intensity at the furnace outlet .

2. Basic Principle

As we know, for medium-capacity boilers, the tangential-firing method possesses high flame fullness, steady combustion, wide adaptation to various fuels and other advantages. And the existence of remaining whirl does not bring about disastrous consequences. But for large-capacity boilers (with capacity over 1000t/h), the result caused by the residual whirl is very serious and unbearable. Because the angular momentum flux at the inlet of the burners and the panel height for large-capacity boilers are far greater than that for medium-capacity boilers. The larger panel height and the greater angular momentum flux are apt to make the air-streams to attach to the wall. In addition, the quantity of heat absorption is increased at the same time, so the harmful effect of residual whirl is doubled, which results in the increase of the heat imbalance of flue gas and steam.

The counter-tangential operation could decrease the intensity of residual whirl. Cold tests and numerical simulation verified this conclusion. But in fact, the result of counter-tangential operation was not so satisfactory as expected in practical operation. The essential cause was that the mode of the counter-tangential operation and the selected kinetic energy flux of the counter-tangential operation were not very reasonable, or at least, the following aspects were ignored:

a. There are significant differences between the cold test and practical operation;
b. The features of tangential firing were not fully considered during the decision of the aim and the mode of the counter-tangential operation.
c. Once the tangential whirl is formed, the cost of angular momentum to depress the whirl is much larger than that of the original angular momentum to establish the whirl, due to the increased angular momentum caused by the wall attachment of the jets.

In order to solve the above-mentioned problems, the controlled whirl method is proposed in this paper. Its basic idea is as follows: At first by the action of proper tangential jets, a certain spin intensity of the whirl is formed. Then the tangential and counter-tangential jets or cross air-jets are progressively added in, maintaining a weak whirl in the furnace, so that the jets may not attach to the wall and the combustion may be steady. So long as the residual spin intensity or the angular momentum flux at the furnace outlet can be controlled within certain extent, the heat imbalance of the flue gas temperature and the steam temperature caused by the residual whirl can be fully controlled.

As we know, the main advantages of the tangential firing are high flame fullness in the furnace and the steady combustion, so when we consider any improvement the steady combustion in the furnace shall be taken into account. In other words, the main advantages of the tangential firing shall be preserved.

The idea proposed in this paper is different from the counter-tangential operation. Not only the starting point, but also the measures and the aims of the two methods are different. It is the starting point of the controlled spin intensity method to control the spin intensity in the furnace to maintain the weak whirl state.

There are two steps for controlled spin intensity method: starting whirl and depressing whirl. They are supplements to each other.

How to start the whirl is the first factor for the success of the controlled spin intensity method. The selection of airflow, air momentum and the angular momentum of the various jets shall comply to the following requirements:

a. No wall attachment of the air-stream;
b. Steady whirl.

And how to depress the whirl is the key of the controlled spin intensity method. It is the crux of success. The whirl-depressing operation is not only a counter-tangential action. It is the rational combination of the counter-tangential jets, the tangential jets and the cross jets. There are some basic principles, which shall be followed during whirl-depressing operation: The whirl-depressing jets shall not distort the main jets. Or at least, after the whirl-depressing jets are fed in, the main gas flow will not be in a disorderly state, which will be harmful to combustion.

The innovation of the controlled spin intensity method lies in the controlled spin intensity and weak whirl state. There are many advantages when the main gas flow in the furnace is kept in the

weak whirl state. First, the weak whirl can effectively prevent the jets from attaching to the wall so as to minimize the slagging and abrasion of the waterwall. Besides if the jets not attach to the wall, its angular momentum will not be increased excessively. Second, the existence of weak whirl will give full play to the advantages of the tangential firing. The combustion core will be easy to establish and maintain. Third, with the existence of the weak whirl, the combustion intensity at the furnace center will be weakened, the combustion temperature and the furnace section heat release rate will be slightly lowered, the formation of NOx will be depressed, and the environmental pollution will be reduced too.

The working mechanism of controlled spin intensity method is as follows: By adjusting the spin intensity of the tangential firing to maintain the weak whirl state, the angular momentum flux of the whirl will be kept in a certain extent. Since the jets do not attach to the wall, the rapid increase of the velocity circulation will be prevented, which is favorable to the whirl depression.

3. Adoptive Measures

In this paper, the angular momentum flux is used to stand for the spin intensity in the furnace. Using the concept of circulation for reference, the definition of angular momentum flux is[1]:

$$S = \int \rho w(ux - vy)dA \qquad (1)$$

Taking the 1960t/h boiler of *Pingwei Power Plant* in *Anhui Province* in *China* as an example, we studied on the angular momentum flux at of the residual whirl the furnace outlet , and some favorable conclusions were obtained.

The isothermalκ -ε double equation mathematical simulation was used in this paper to analyze preliminarily the regular pattern of the attenuation of the angular momentum in the furnace.

Where the gas density (ρ) is defined as a constant.

In the calculation, the SIMPLEC algorithm, the criss-cross grid and the QUICK difference format were used for the gas flow field. The temperature in the furnace is supposed to be constant (1500K)

Wall function method was used to take account of the waterwall of the boiler, and the roughness method was used to rectify the results[2].

4. Result Analysis

A total of 6 operating modes were studied in this paper.

5. Conclusions

1) It is better to depressing whirl in time, because it is profitable to control the spin intensity in the furnace.
2) In order to maintain the spin direction of the whirl in the furnace, it is important to control the quantity and distribution of the air jets to start the whirl.
3) It is better to depressing the whirl in weak spin state.
4) When the mere tertiary air is utilized to depressing whirl, the result will not be reliable.
5) The range of the angular momentum flux of the residual whirl at the furnace outlet ought to be determined from the study of the heat imbalance of the panel zone.

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