Application of a method for calculating coal quantity feed into boiler for double inlet and outlet ball mill in the coordinated control system

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Abstract. Accuracy of the measurement of coal quantity feed into the boiler furnace has great influence on the combustion and coordinated control of power plant. According to the characteristics of double inlet and outlet mill pulverizing system, the method of calculating the amount of coal into furnace using the correlated variable was presented. On this basis, the coordinated control system was designed. Running results show that the method of calculating the fuel quantity accurately and effectively guarantee the stability of coordinated control system. It has a high adjustment quality.

1. Introduction

Double inlet and outlet mill pulverizing system (DIOMPS) has been widely used because of its characteristics of high reliability, good adaptability to various coals, and rapid response to the varying load of the boiler [1, 2]. In contrast to the medium speed mill pulverizing system, the coal quantity feed into the boiler furnace of the DIOMPS is calculated from capacity air volume rather than the coal quantity of the feeder [3, 4]. However, because of the influences of poor installation and calibration, bad operating environment of the measuring equipment, and block of the sampling hole, the measuring result of the capacity air volume of the mill is not reliable, and there is a great error between the calculating and practical quantity of the coal supply. Therefore, this error easily leads to great fluctuation of the main operating parameters and even failures of the coordination system, which greatly affects the stability and safety of the thermal power unit [5, 6]. It is helpful to improve the combustion and coordination control and enhance the stability and economic efficiency of a thermal power unit by solving the problem of coal measurement of the DIOMPS.

2. Characteristics analysis of the DIOMPS

In the DIOMPS, cold and hot primary air is mixed at the inlet of the mill. The temperature and velocity of the coal and air mixture at the outlet of the mill is controlled by adjusting the ratio of the cold to hot primary air. The capacity air flows through the mill and brings the coal to the separator. Big coal cakes go back into the mill to be grinded and fine coal particles are carried into the boiler furnace by the primary air. The quantity of the coal feed into the boiler furnace is related to the primary air volume (capacity air volume) in the mill. The coal quantity feed into the boiler furnace is nearly proportional to the capacity air volume when the material level in the mill is steady. The capacity air volume depends mainly on the capacity valve opening and pressure of the primary air. Consequently, the coal quantity feed into the boiler furnace from the DIOMPS is mainly relative to the capacity valve opening, pressure...
of the primary air, and material level in the mill. So far, coal quantity of a DIOMPS is usually monotonously characterized by capacity air volume of the mill, and the calculating result is used for coordination control [7, 8]. The quality of the coordination control is greatly affected by the accuracy of the measurement of the capacity air volume, which should be improved.

3. Method for calculating the coal quantity feed into boiler of the DIOMPS

According to the analysis of the operating parameters of the unit and features of the equipment, the coal quantity feed into the boiler furnace from the DIOMPS is strongly related to the capacity valve opening, pressure of the primary air, and material level in the mill [9]. As a result, the coal quantity, defined as simulating coal quantity, is calculated by coupling the capacity valve opening, pressure of the primary air, and material level in the ball mill.

The simulating coal quantity is calculated by multiply the function of the capacity valve opening, function of the pressure of the primary air and function of the material level. The functions of the three variables are used to correct the simulating coal quantity by an inertial element. The calculating formula is as follows:

\[ F = f(C) \times f(P) \times f(L) \times LAG(C) \times LAG(P) \times LAG(L) \]  

Where, \( F \) is simulating coal quantity; \( C \) is capacity valve opening; \( P \) is pressure of the primary air; \( L \) is material level in the mill; \( LAG(C), LAG(P) \) and \( LAG(L) \) is the inertial element of capacity valve opening, pressure of the primary air and material level in the mill, respectively. The quality of the measuring pressure of the primary and feedback of the capacity valve opening is justified before simulating coal quantity calculation. The hot primary air pressure replaces the primary air pressure at the mill inlet when the quality of the latter is bad. The command of the capacity valve opening replaces the feedback of the capacity valve opening when the quality of the latter is bad. When the quality of the material level becomes bad, the measurement value remains as same as the one of the front moment. The coal quantity is regarded as zero when the corresponding mill does not run. The total coal quantity is the sum of simulating coal quantity of the all operating mills.

By using the simulating coal quantity as the actual coal quantity feed into the boiler furnace, the coordinated control system of power plant unit was designed. The strategy of boiler master control, turbine control, and fuel control is similar to that of the conventional coordinated control system, which will not be explained in detail.

4. Application of the coordinated control system based on simulating coal quantity

The coordinated control system based on simulating coal quantity has been commissioned and applied in a 630MW supercritical unit. Running results show that the coordinated control system based on simulating coal quantity has excellent regulation quality and can meet the requirements of unit operation.

4.1. Results of steady state test

The unit was maintained at the stable operation in coordinate mode. The main automatic control system of coordination, fuel, and boiler feed water and steam temperature kept operating. The unit load was about 480MW. The setting value of main stream pressure was 19.63MPa and main steam temperature was 565°C. The trend of main parameters of the unit was shown in Figure 1. The total simulating coal quantity is basically same as the total feed coal quantity during steady state operation (Fig. 1), indicating that the model of simulating coal quantity was accurate. During steady state test, the maximum deviation between main steam pressure and its setting value was -0.23MPa, the maximum deviation between main steam temperature and its setting value was -1.8°C, and the maximum deviation between reheated steam temperature and its setting value was 3.2°C. The above indexes are superior to the relevant technique regulations requirements.
4.2. Results of down load test
The load was decreased from 630MW to 530MW in coordinate mode, of which the variation amplitude was about 100MW, and varying rate was 10MW/min. The trend of main parameters of the unit during the down load test is shown in Figure 2. Figure 2 shows that the total simulating coal quantity is close to the total coal feed quantity when load is stable. As the load changed, there is a large deviation between the total simulating coal quantity and the total coal feed quantity, and the maximum deviation is 88t/h. The total coal feed quantity is no longer able to characterize the coal quantity feed into the boiler furnace. During the load down test, the maximum deviation between load and load command is -3.2MW, the maximum deviation between main steam pressure and its setting value is -0.50MPa, the maximum deviation between main steam temperature and its setting value is 4.8℃, and the maximum deviation between reheated steam temperature and its setting value is -6.0℃. The results are better than the standards of the relevant technique regulations. The test shows that the coordinated control system based on simulating coal quantity accurately calculates the fuel and meets the requirements of thermal power unit operation.

![Figure 1. Trend of main parameters of steady state test](image1)

![Figure 2. Trend of main parameters of down load test](image2)
4.3. Results of up load test
The load was increased from 450MW to 550MW in coordinate mode, of which the variation amplitude was about 100MW and varying rate was 10MW/min. The trend of main parameters of the unit during the up load test was shown in Figure 3. The total simulating coal quantity was very close to the total coal feed quantity when the unit is running at stable state without load change. The deviation between the total simulating coal quantity and total coal feed quantity becomes large when the load is changed. During the test, the maximum deviation between load and load command is -3.2MW. The maximum deviation between main steam pressure and its setting value is -0.45MPa. The maximum deviation between main steam temperature and its setting value is -4.5℃. The maximum deviation between reheated steam temperature and its setting value is -5.5℃. It meets the requirements of unit operation.

![Figure 3. Trend of main parameters of up load test](image)

5. Conclusion
A method of calculating the coal quantity feed into the boiler furnace by multiply the function of the capacity valve opening, function of the pressure of the primary air and function of the material level is presented, and the method is applied to the coordinated control system in a 630MW supercritical unit.

The application results show that the total simulating coal quantity is almost the same as the total coal feed quantity and the deviation between them is slight under the stable state. However, the coal feed quantity is unable to characterize the coal quantity feed into the boiler furnace when the load is changing. During the test of down load and up load, the maximum deviation between main steam pressure and its setting value are -0.50MPa and -0.45MPa, the maximum deviation between main steam temperature and its setting value are 4.8℃ and -4.5℃, respectively. The test results show that the proposed coordinated control system based on the simulating coal quantity has high quality and can meet the requirements of normal operation of the unit, which can provide a reference for the similar type of thermal power unit.

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