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# Rapping Strategy and Electric Field Characteristics of ESP in a Power Plant

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***Abstract*—The electric field operating and rapping parameters of 1# Electrostatic Precipitators (ESP) had been monitored and analysed in a thermal power company. There were five electric fields in the ESP. The rapping time of 1# ESP was 150 seconds. The time interval when the rapping was stopped increased sequentially from the first to the fifth electrical field, and the neighbouring two electric fields did not overlap each other. The operating voltage in 1# ESP also went up sequentially from the first to the fifth electrical field. The secondary voltage and current of each electric field was closely related to the rapping interval. The total energy consumption was suggested to be 26.6-29 kW to keep the dust emission under 20 mg/Nm³.**

***Keywords—rapping parameters; secondary voltage and current; ESP; energy consumption component;***

## I. INTRODUCTION

ESP is a traditional dust control technology of the flue gas. The particulate matter is charged and collected by the electrical field. As the ESP operating time increases, a dust layer forms on the collecting plate of the electrical field, which reduces the corona voltage electrode and the dust removal efficiency [1]. Therefore, the dust cleaning of the collecting plate plays a crucial role in the ESP operation.

The dust layer cleaning mainly adopts mechanical rapping. The rapping strategy is related to the electrical field configurations and the rapping parameters such as the rapping time and the rapping interval, are the key factors. If the rapping interval is too short, the dust taken out by the flue gas will greatly increase to directly reduce the dust removal efficiency [2]. This paper displayed an optimized rapping strategy of 1# ESP in a thermal power company in Shanxi for the ultra-low emission, as well as the voltage and current characteristic.

## II. ESP RAPPING STRATEGY AND ELECTRICAL FIELD CHARACTERISTICS

The 1# 330MW heating unit of Shanxi Thermal Power Co., Ltd. had a horizontal ESP with five chambers. The specific design parameters were shown in Table 1.

The rapping strategy of the collecting plate consisted of the rapping time and the rapping interval. During the cleaning process, the accumulated dust layer fell off into the bottom ash bucket under the guidance of gravity [3]. Table 2 displayed the rapping time and the rapping interval in 1# ESP. The rapping time in each electric field was the same, 150s. The rapping interval increased sequentially from the first to the fifth electrical field as the dust load gradually decreased.

TABLE I. ESP DESIGH PARAMETERS

| ESP specifications | Design parameter |
|---|---|
| Single chamber Effective area / m² | 60 |
| Distance of single channel / mm | 405 |
| Number of power supply | 12 |
| Form of Rapping system | Rotary hammer |
| Total Collection area / m² | 18000 |
| Flue gas flow rate / m³/s | 159.3 |
| Air leakage rate / % | ≤2.5 |
| Body resistance / Pa | ≤245 |
| Retention time / s | 21.4 |

TABLE II. ESP RAPPING CYCLE

| Electrical field | Rapping time / s | Rapping interval / s |
|---|---|---|
| First | 150 | 300 |
| Sencond | 150 | 480 |
| Third | 150 | 720 |
| Fourth | 150 | 900 |
| Fifth | 150 | 1080 |

If the rapping of two adjacent electric fields are carried out simultaneously, secondary dust will be generated and total dust removal efficiency will be reduced. Therefore, the rapping cycle should meet the standard that the rapping of any two adjacent electric fields has to be stagger. In Figure 1 the rapping cycle of 1# ESP was shown. The peaks represented the rapping time and the interval between two peaks was the rapping break. The rapping time of each electrical field was the same as the collecting plates were the same. The rapping interval increased gradually from the first electrical field to the fifth electrical field as the dust load decreased for the electrical fields. The rapping time (peak) between the adjacent two electric fields is basically satisfied and does not overlap [4]. But when the fifth electrical field was rapping, the first and the second electrical fields were nearly rapping at the same time periodically. It was deduced that every 8-11 minutes the dust load of the third, the fourth and the fifth electrical fields would went up and the electrical characteristics had sharp fluctuation.

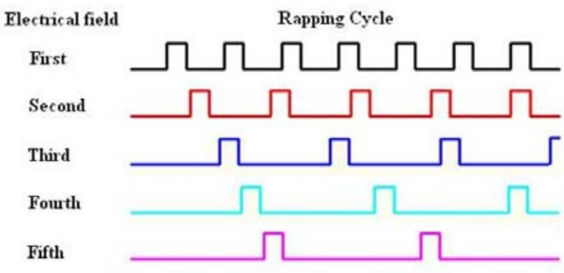


FIGURE I. 1# ESP RAPPING CYCLE

To meet the ultra-low emission standards of coal-fired power plants, the power supply system of the first electrical field has been improved in 1# ESP. Power was supplied by two sources called Source A and Source B, which aimed to increase the dust removal efficiency of the first electrical field and reduce the dust load of the remaining electric fields. Figure 2 displaces the electric fields in 1# ESP.

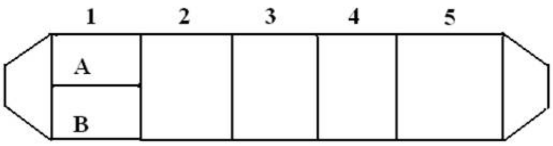


FIGURE II. TOP VIEW OF THE ELECTRIC FIELDS IN 1# ESP

The distribution of electric field voltages during the ESP operation greatly affects the dust removal efficiency and power consumption. Thus, the secondary voltage and secondary current of each electric field in 1# ESP were detected and shown in Figure 3. With the accumulation of dust on the collecting plate and the plate rapping, the secondary voltage had obvious fluctuations. Generally, the secondary voltage went up from the first electrical field to the fifth electrical field: fifth > fourth > third > secondary > first A = first B.

In order to prevent secondary dust and to meet the ultra-low dust emission standard, the secondary voltage of the fourth and the fifth electric fields were higher. The peak value was 47 kV and 53 KV, respectively. The secondary voltage gradually decreased in the fourth and fifth electric fields as the dust was smaller than the front electric fields and was difficult to remove from the collecting plate with SO3 and H2O adsorption [5]. The secondary voltage in the fourth and fifth electric fields seemed to change periodically every 8-11 minutes according to the rapping cycle. The secondary voltages of the first, second and third electric fields were relatively stable and fluctuated with the rapping strategy. First electric field A and First electric field B had the same inlet dust load, and the secondary voltage was very close and stable.

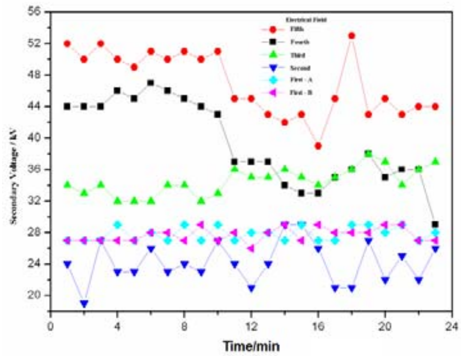


FIGURE III. SECONDARY VOLTAGES OF DIFFERENT ELECTRIC FIELDS IN 1# ESP

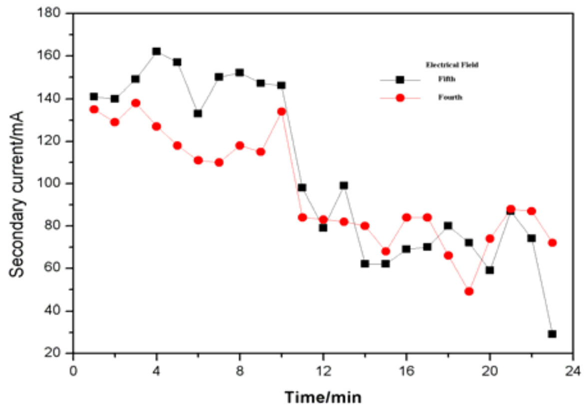


FIGURE IV. SECONDARY CURRENT OF DIFFERENT ELECTRICAL FIELDS IN 1# ESP

Since the secondary voltage in the fourth and fifth electric fields had higher vibrations than the front three electrical fields, the secondary current of the fourth and the fifth electric fields were emphasized in Figure 4. Similar to the voltage tendency, the second current of the four and the fifth electric fields went down sharply every 8-11 minutes according to the rapping strategy.

In order to better investigate the stability of the corona discharge in 1# ESP, the secondary voltage and the secondary current of the fourth and the fifth electric fields were fitted into a volt-ampere characteristic curve, as illustrated in Figure 5. In the two electric fields, the voltage and the related current were positively correlated and the correlation was linear during operation, which plays an important role in the ESP operation [6].

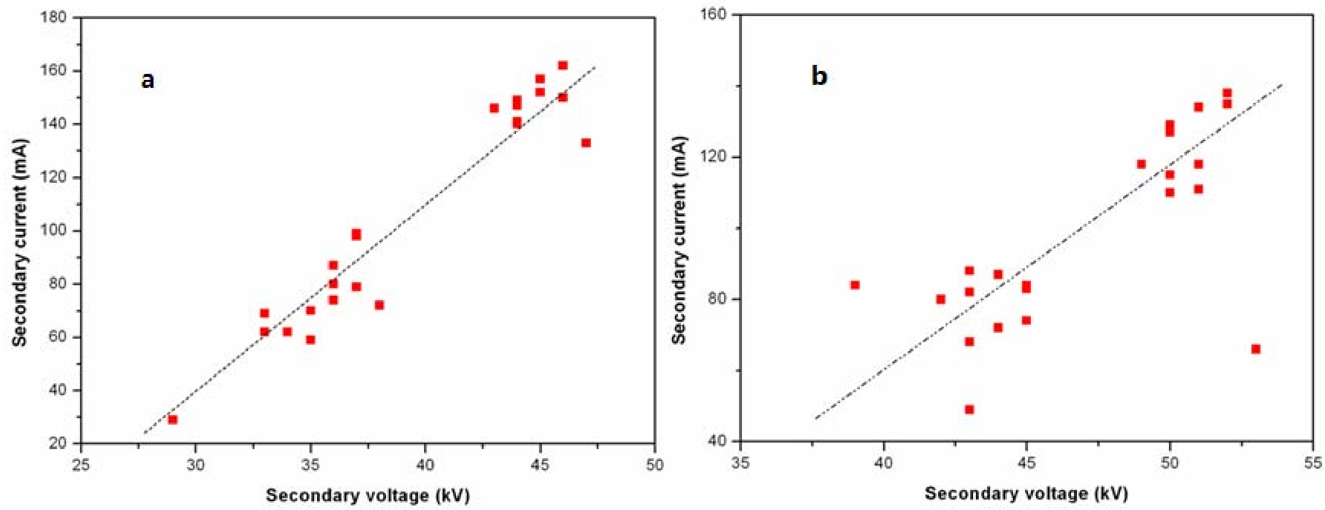


FIGURE V. VOLT-AMPERE CHARACTERISTICS OF DIFFERENT ELECTRICAL FIELDS IN 1#ESP (A-THE FOURTH ELECTRICAL FIELD; B- THE FIFTH ELECTRICAL FIELD)

The energy consumption of each electrical fields and the relative dust emission of 1# ESP were shown in Table 3. The total energy consumption was also calculated. The higher the total energy consumption was, the lower the dust emission was [7]. The energy consumption of the first electrical field was the sum of the electrical field A and B, which was the largest in all the electrical fields. At a total energy consumption of 25439 W and 33082 W, the dust emission was 24 mg/Nm3 and 11 mg/Nm3, respectively.

TABLE III. ENERGY CONSUMPTION AND OUTLET DUST CONCENTRATION OF 1# ESP TABLE 1 ESP DESIGN PARAMETERS

| Energy consumption of the electrical field (W) | | | | | | Dust emission ($mg/Nm^3$) |
|---|---|---|---|---|---|---|
| **First** | **Second** | **Third** | **Fourth** | **Fifth** | **Total** | |
| 13224 | 5610 | 4176 | 2727 | 3186 | 28923 | 19 |
| 12610 | 8877 | 4710 | 2997 | 3888 | 33082 | 11 |
| 11912 | 4640 | 3178 | 2464 | 4452 | 26646 | 23 |
| 12858 | 8772 | 4320 | 2784 | 3780 | 32514 | 12 |
| 10658 | 5130 | 3491 | 3248 | 2912 | 25439 | 24 |
| 9916 | 7772 | 4925 | 2813 | 4582 | 30008 | 13 |

ESP is usually located in the middle of the flue gas control process. The desulfurization reactor is the next treating equipment after ESP. As desulfurization dust will form from the desulfurization reactor, the dust emission from ESP is not necessary to meet the ultra-low standard, which will significantly reduce the energy consumption of ESP. Therefore, the energy consumption is suggested to be 26600-29000 W, which maintains the dust emission lower than 20mg/Nm3 and consumes less energy.

## III. CONCLUSION

The rapping strategy and electric field characteristic in 1# ESP in Shanxi was analyzed. The rapping strategy involved two key parameters, the rapping time and the rapping interval. The rapping time of all the electrical fields were the same and the rapping interval grew up sequentially from the first to the fifth electrical field. When the rapping time of adjacent two electric fields overlapped, the electrical characteristic was greatly affected of the fourth and the fifth electrical fields with sharply reducing secondary voltage and current, as the dust load went up. The total energy consumption of 1# ESP increased when the dust emission fell down. As ESP located in the middle of the flue gas control process, the dust emission of ESP does not represent the outlet dust emitted from the chimney. Therefore, the dust emission of ESP lower than 20 mg/Nm3 can be accepted and the energy consumption can be reduced to 26600 - 29000 W.

## ACKNOWLEDGMENT

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