Industrial Applications of a New AVC for Upgrading ESP to Save Energy and Improve Efficiency

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Abstract: This paper reports one demonstration investigation on one new automatic voltage controller (AVC) named ZH2005 to improve dust collection efficiency and save energy consumption. Experiments were performed with a 200 MW coal-fired boiler owned by Huaneng Beijing Cogeneration Co., Ltd. Energization methods, such as simple-pulsing, spark-rate control, intermittent energization and ZH2005 method, were adopted for evaluation of both dust emission and energy consumption. After almost one-year utilization, we conclude that the ZH2005 can keep outlet dust emission to be below 20mg/Nm^3 and/or a total dust reduction of about 120T per year with an energy-saving of about 70% or 1260 MWh.

Keywords: Automatic voltage controller, Back corona, ESP upgrading

1 INTRODUCTION

ESP has been one of the most popular dust collection techniques for coal-fired power plants. In comparison with developed regions, where the emission is usually around 10 mg/Nm^3–20 mg/Nm^3[1], around 90% of Chinese ESPs still give a dust emission of over 50 mg/Nm^3. As a result, there is a big health issue caused by $PM_{2.5}$ [2,3].

Generally speaking, collection of particles with diameters of larger than 10μm is dominated by applied electrostatic and Stocks drag forces as illustrated by the Deutsch equation. For $PM_{2.5}$ collection, however, three following aspects can significantly affect its efficiency, namely:

1) Insufficient charging due to a low applied voltage, which leads to non-uniform discharge and low ion density [4];
2) Reentrainment due to EHD induced ion's wind [5];
3) Reentrainment caused by back corona and not optimal rapping in the last field [6].

With regard to today's Chinese ESP and power utilities, both dust emission and energy consumption have become enabling technical and economical issues for applications of any new techniques.

This paper presents one of our recent industrial demonstration studies to match the latest Beijing dust emission standard DB11/139-2007, which has been applied since July 1, 2008.

2 ESP AND FLUE GAS

The two-channels and four-fields ESP has been used for about 10 years, and the inlet and outlet dust concentrations were around 7 g/m^3 and 50 mg/m^3, respectively [7] To match the standard, the maximum dust emission must be less than 20 mg/m^3. In fact, this is the main reason to upgrade the power sources.

It is 400 mm gap ESP with a total collection surface of 18584 m^2 and a SCA value of 52.19 m^2/(m^3/s). The gaseous residence time and velocity inside ESP are around 10.43 s and 1.15 m/s, respectively. And the gaseous temperature and flow rate are around 112 ℃-118 ℃ and 131750 m^3/h, respectively. The ESP height is 12.05 m. Eight traditional Chinese made T/R has voltage and current ratings of 72 kV/1.2 A, respectively.

Fig. 1 shows typical fraction and cumulative mass distributions for collected ash at different ESP fields. The mean diameters for inlet, the second, the third and the outlet field are 18.87 μm, 8.78 μm, 5.59 μm and 4.87 μm, respectively. Table 1 lists ash resistivity.

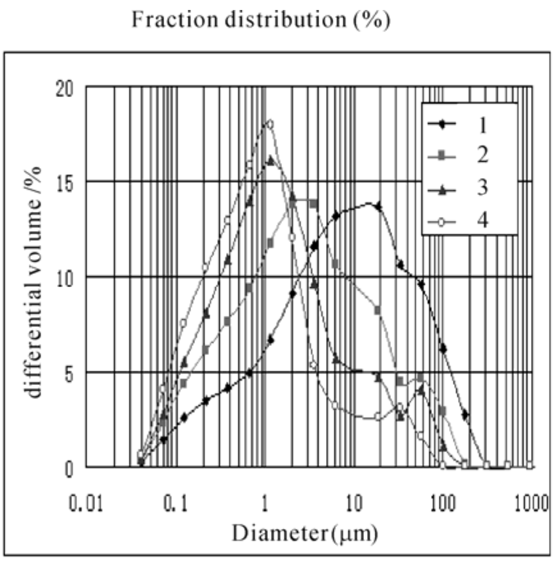
3 POWER SOURCE UPGRADING

The eight old automatic voltage controllers (AVC) were based on spark-rate limited control methodology. Considering the ash resistivity as listed in Table 1 and our experience with both three-phase and single-phase T/Rs [8], we can conclude that the old AVC can not provide any optimal performance for either dust emission or the energy saving. Back corona will play a very critical role to affect the performance.

In order to achieve optimal performance, the upgrading includes replacement of the eight old AVCs by using eight new-type ZH2005 AVCs. We also applied two low-voltage controllers and one supervisory computer to match the AVC. It took about two weeks to finish the upgrading work, and so far the system has been in operation for over a year without any troubles. The adopted methodology is mainly based on early experimental observation by Masuda and Mizuno on the V-I map for various discharge modes [9]. A better ESP performance can be always achieved by keeping a high voltage but a low current.

4 RESULTS AND DISCUSSIONS

In order to optimize the ESP performance, a series of experimental investigations were performed within several months. Table 2 lists one typical example with regard to dust emission and total power consumption. The energization methods include spark-rate limited, I.E., simple-pulsing and ZH2005. Fig. 2 shows on-line measurements under those energization methods. For each method, experiments were performed for two hours. Spark-rated limited method gives the highest dust emission. I.E. mode achieves the greatest energy saving. Considering both emission and energy saving, ZH2005 provides optimal performance as shown in Table 2 and Fig. 2. Based on over one year industrial observation, more than 440 MWh of energy can be saved, and more than 120T of dust is collected.



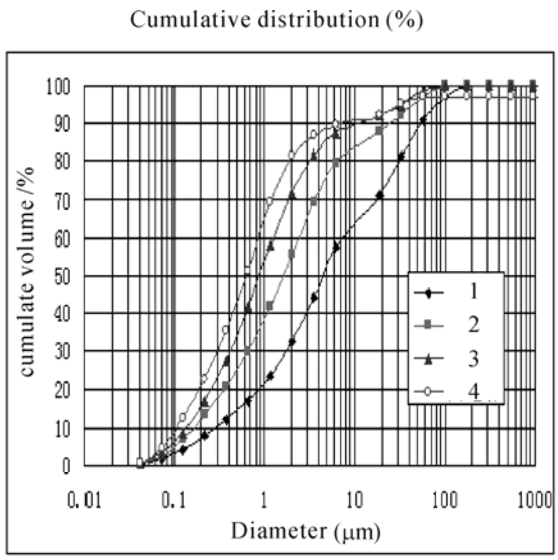


Table 1 Ash resistivity for all fields (Ω·cm)

Temp	1	2	3	4
100 (□)	1.45×10^{10}	2.70×10^{10}	5.00×10^{10}	6.80×10^{10}
120 (□)	6.20×10^{10}	1.55×10^{11}	3.30×10^{11}	4.30×10^{11}
150 (□)	4.50×10^{11}	7.20×10^{11}	8.60×10^{11}	6.50×10^{11}
180 (□)	1.80×10^{11}	1.65×10^{11}	1.50×10^{11}	1.00×10^{11}

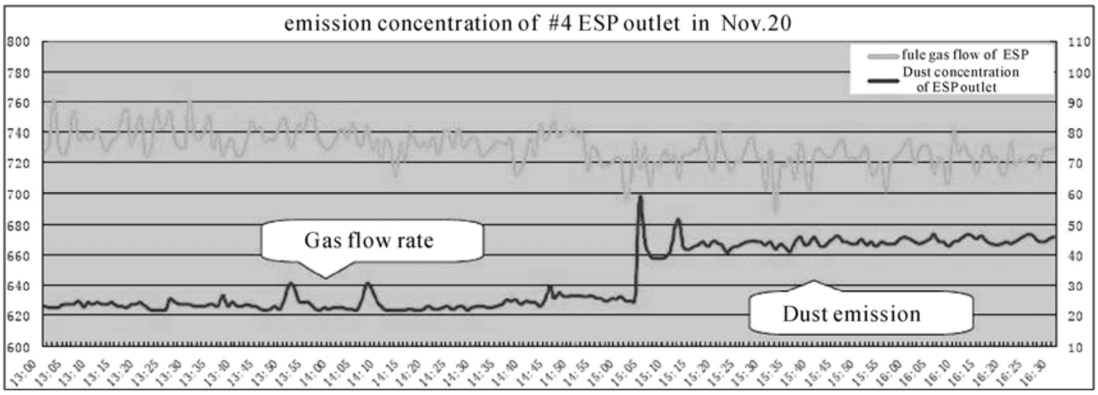
Table 2 Comparison of dust emission and energy saving under various energization methods

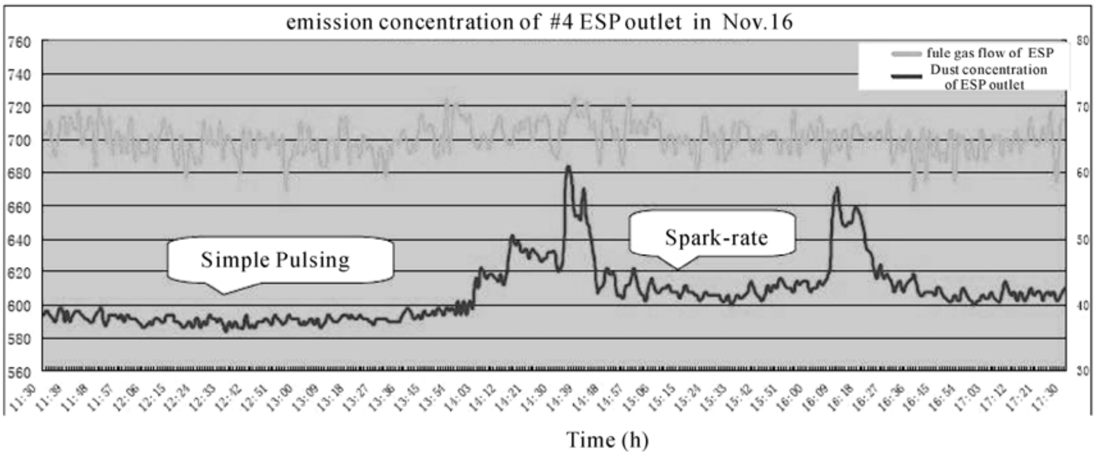
	Simple pulsing	Spark-rate limited	ZH2005	I.E.
Total power	269.5 kW	86.3-99.2 kW	100.2 kW	60.3 kW
Energy saving	68%	63%	62.8%	77.6%
Emission	49 mg/m^3	38- 46 mg/m^3	22 mg/m^3	44 mg/m^3
Emission reduction	22%	6%	55%	10%

5 CONCLUSIONS

There are urgent needs for Chinese utilities to upgrade their ESP performance, for which almost 80% of them has problems caused by back corona.

By controlling back corona as shown via the V-I curve and rapping properly, both dust emission and energy consumption can be simultaneously optimized. Our industrial results demonstrated that it is possible to limit outlet emission of less than 20 mg/m^3 for four- and/or five-fields ESP. We anticipate that more Chinese electricity utilities will adopt the proposed method for their applications.





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