Research on Performance of Electrostatic–Bag Precipitator with Comparative Industrial Tests

DANG Xiaoqing, SHI Yong, MA Guangda, LI Dongyang
(School of Environmental and Municipal Engineering;
Xi'an University of Architecture and Technology, Xi'an 710055, PR China)

Abstract: The industrial tests made a comparison of three key factors under different filtration velocities, which comprised the outlet emission concentration of dust, grade collection efficiency of PM10 and the rising rate of pressure drop .Meanwhile, the paper provided the reasonable scope of filtration velocity of EBP through the tests, which was helpful for the design and application of large-scale EBP.

Keywords: EBP, PM_{10}, Grade collection efficiency, Pressure drop

1 INTRODUCTION

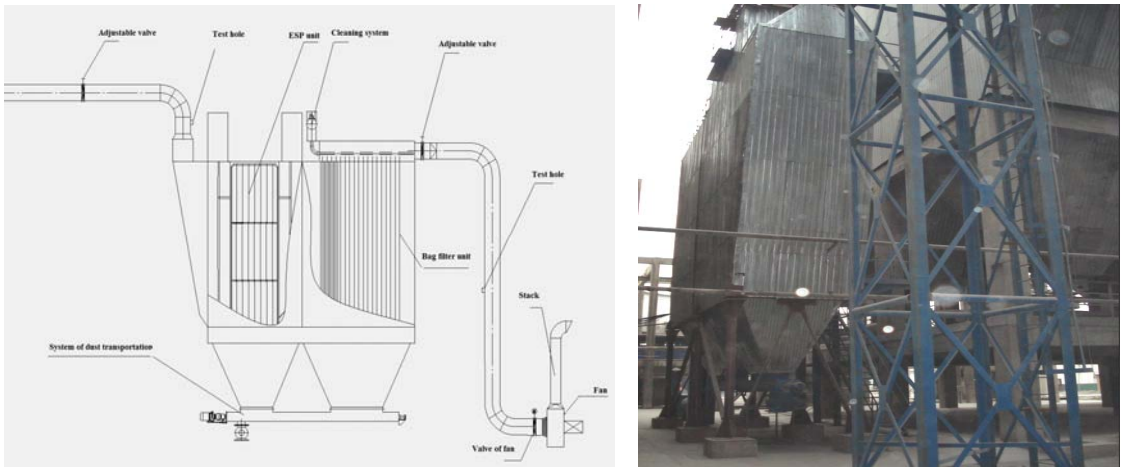
Electrostatic–bag precipitator(EBP) is characterized by a lower-running resistance, long life filter, high efficiency of trapping the fine particles, It has been applied in some coal-fired power plants in China [1-2]. For further research and application, we need to solve two problems on how to control the gas flow distribution and how to select the design parameters and operation parameters of large-scale EBP [3].

The authors made research on EBP through industrial tests. The tests were carried out in a 160MWe coal-fired power plant. The maximum gas flow rate was 20,000 m^3 / h. On the condition that the tests of gas flow distribution and optimization tests of electrode configuration were completed [4-7], the purpose of the tests were mainly to study and optimize the EBP's design parameters and operation parameters. Under different filtration velocities, the tests made a comparison between bag filter and EBP on the outlet emission concentration of fly ash, the grade collection efficiency of PM_{10} and the rising rate of pressure drop, ascertaining a reasonable scope of filtration velocity, cleaning cycle .The tests provided the basic reference data for the design of the large-scale EBP [8-12].

2 TEST EAUIPMENT AND METHODS

2.1 Test equipment and the main parameters

Test equipment is shown in Fig. 1..



(a) Industrial test system of EBP (b) Overall view of EBP

Fig. 1 Structure of EBP system

The flue gas was introduced from the preheater of the boiler into the EBP on condition the boiler was operated normal, and then exhausted from the stack. Adjustable valves were set in the system in order to control the filtration velocity.

The EBP was composed of electrostatic precipitator unit (ESP unit) and bag filter unit (BF unit). After being fully charged, parts of particles were collected by the ESP unit, and the rest went into the BF unit (long bag low pressure precipitator unit) with the flue gas. Through the filtration of BF unit, the flue gas finally exhausted from the upper tank of BF unit. When the ESP unit didn't work we viewed the EBP as a bag filter. The main parameters of EBP are shown in Table 1.

Table 1 characteristics of EBP

No	parameter	Unit	Value
1	Number of electrical fields		1
2	Passages		5
3	Plate spacing	mm	400
4	Effective length	mm	1900
5	Effective height	mm	7000
6	Bags dimensions	mm	Φ130×6000
7	Active area of filtration	m^2	2×176.5
8	Pressure of cleaning	kPa	2.0

2.2 Test methods

The rising rate of Pressure drop is shown by pressure drop-time (P-t) linear relation.. Under the mode of cleaning dust by fixed pressure, P-t line is drawn by testing the pressure drop between the middle tank and the upper tank of BF unit with U-pressure gauge. Pulse valve began to clean dust, when the pressure drop approached 1000 Pa The inlet and outlet concentrations of fly ash were tested through 3012H Automatic particles tester by sampling at the same time , then were calculated in accordance with testing standards. Meanwhile, the inlet dust particle size distribution was analyzed by using laser particle size distribution LS230/SVMF Tester [13-14]. Calculations were on the assumption that all outlet particles sampled were PM_{10}.

Collection efficiency and PM_{10} grade collection efficiency under different conditions were calculated by the following formulas:

$$\eta = 1-(1+\alpha)\frac{c''}{c'} \tag{1}$$

$$\eta_{PM10} = 1-(1+\alpha)\frac{c''\times g''}{c'\times g'} \tag{2}$$

Where: α—leakage rate of gas (%)

c'—inlet dust concentration (g/m^3)

c''—outlet dust concentration (g/m^3)

g', g''—Inlet, outlet quality frequency distribution of PM_{10} respectively.

3 RESULTS AND ANALYSIS

All items of tests began after the EBP had run into operation in the power plant for one month, the purpose of which is to let bag filter residual resistance be stable.

3.1 P-t Test results

Under five different filtration velocities, the tests made a comparison of the effect that ESP unit made on the pressure drop of EBP when it worked or not. P-t relations of such conditions are shown in Figs. 2 and 3 respectively. The results showed that the rising rate of pressure drop in bag filter (BF unit) and EBP increased as filtration velocity rose. Fig 4 showed the P-t linear relation of EBP under different filtration velocities. It indicated that when filtration velocity was below 1.7 m/min, the rising rate of pressure drop in EBP was lower than in bag filter under the same filtration velocity. At the same time, it also showed that when filtration velocity approached 1.7 m/min, the rising rate of pressure drop in bag filter and EBP increased obviously, the gap of which was very small. In other words, EBP has no advantage over bag filter in the scope of filtration velocity.

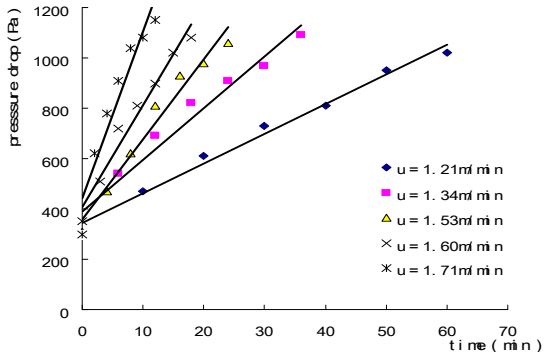


Fig. 2 Pressure drop versus time

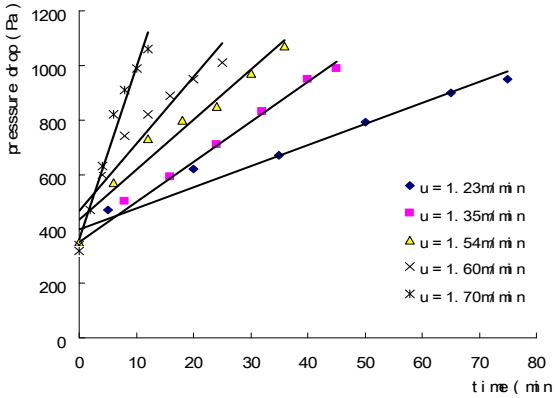
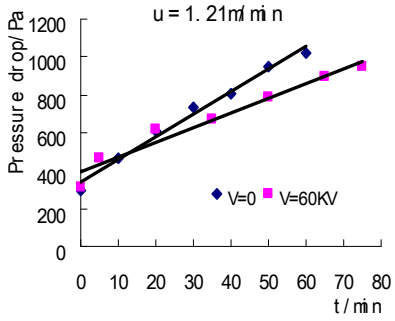
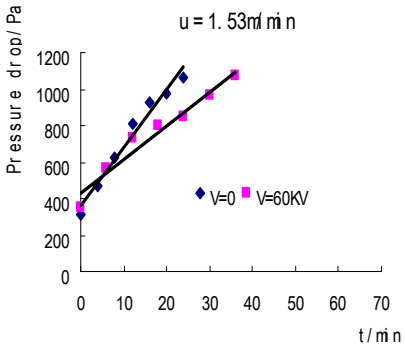


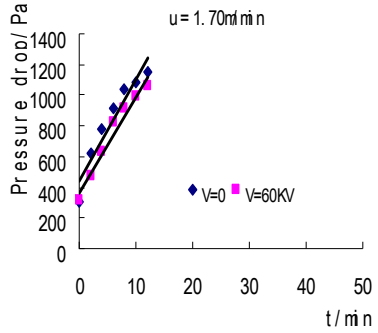
Fig. 3 Pressure drop versus time



(a) u=1.21m/min



(b) u=1.53m/min



(c) u=1.70m/min

Fig. 4 Pressure drop versus time

3.2 Results of collection efficiency and analysis

Figs.5 and 6 showed the outlet dust concentration and PM_{10} emission rate of bag filter and EBP respectively under five different filtration velocities. The results indicate that:

(1) Under five different filtration velocities, all outlet dust concentrations of EBP are less than 20 mg/Nm^3, far less than the regulated value (under 50 mg/Nm^3)of Air Pollutant Emission Standards of China in Power Plant (GB13223-2003)

(2) At the same filtration velocity, grade collection efficiency of PM_{10} of EBP is higher than that of bag filter. So we can also conclude that electrostatic capacity can enhance the trap function of fine particles. of superficial dust layer of bag filter.

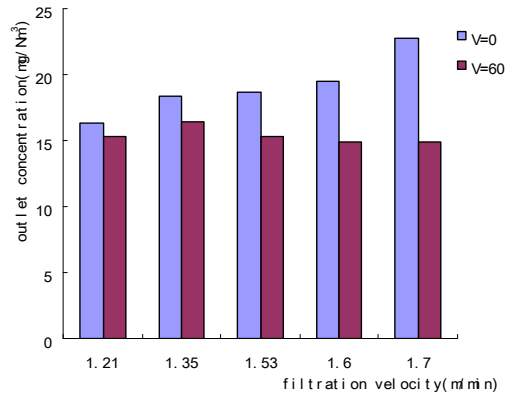


Fig. 5 Filtration velocity and outlet concentration of PM_{10}

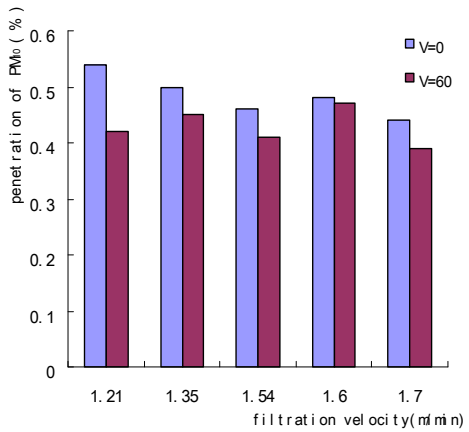


Fig. 6 Filtration velocity and penetration rate of PM_{10}

3.3 Filtration velocity

Fig. 7 showed the relationship between the pressure drop of the EBP and the filtration velocity. It indicated that all the pressure drops of EBP were less than 800 Pa under the filtration velocity of 1.21, 1.3, 1.53 and 1.6m/min.

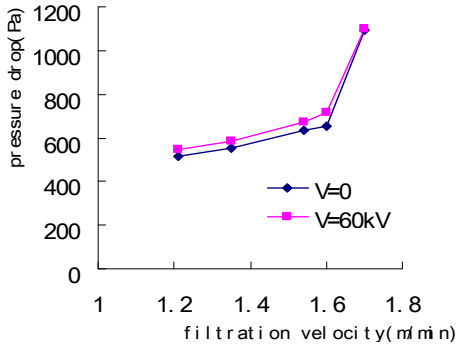


Fig. 7 Pressure drop of the EBP and the filtration velocity

4 CONCLUSIONS

(1) Tests results show that ,at the same filtration velocity, compared with bag filter, EBP had an significant advantage on improving the collection efficiency of fine particles, and lowering the pressure drop of EBP and the rising rate of pressure drop.

(2) During the tests, we also found that when voltage of ESP unit was 60 kV, and filtration velocity was 1.60 m/min, the rising rate of pressure drop was 25 Pa/min, cleaning cycle is 13min (when pressure of EBP reach 1000 Pa, it begin to clean) and the outlet dust concentration was 14.9 mg/m^3. Under such condition, EBP operated very well.

(3) Reasonable scope of filtration velocity and corresponding cleaning cycle were ascertained from the tests. It would be helpful for the design and operation of large-scale EBP.

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