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Translated Paper

Influence of operating temperature on performance of electrostatic precipitator for pulverized coal combustion boiler ☆

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ABSTRACT

Electrostatic precipitator (ESP) is a major dust collection device used in pulverized coal combustion boilers in Japan. Although the collection efficiency of ESP is over 99%, the performance of ESP is affected by dust properties, especially the electric resistivity of the dust. In Japan, many different kinds of coal are used in pulverized coal combustion boilers. The property of coal ash formed in pulverized coal combustion is different for different coals. It is very important to develop high performance ESPs for different kinds of coal ash. In general, the low temperature ESP operated at about 423 K has been used for a long time, but the electric resistivity of some kinds of coal ash is higher than suitable for the ESP in this temperature range. A high temperature ESP operated at 623 K was developed about 20 years ago and an advanced low temperature ESP operated at 373 K has been used recently for control of the electric resistivity of coal ash.

In this paper, we report on the influence of operating temperature from 363 K to 623 K on performance of ESP for a pulverized coal combustion boiler. The influence of coal ash properties including electric resistivity, alkali metal concentration, and operating condition on collection efficiency of an ESP is estimated.

1. Introduction

Coal is an important energy resource because it has more abundant reserves than other fossil fuels such as oil and natural gas, and coal is mined in various countries. However various impurities, such as ash, nitrogen, and sulfur, are contained in coal, requiring application of emission control technology to use coal cleanly. Electrostatic precipitators (ESP) and bag-filters provide highly efficiency dust collection technology. The pressure loss is lower in ESP than in bag filters, and ESP is appropriate at large scale. Therefore ESP is the major dust collection technology used in pulverized coal combustion boilers in Japan. Although the collection efficiency of ESP is over 99%, the performance of ESP is affected by the dust properties, especially the electric resistivity of the dust. In Japan, many different kinds of coal are imported from overseas countries and used in pulverized coal combustion boilers. The properties of the coal ash formed in pulverized coal combustion is different depending on the coal species. Therefore it is very important to develop high performance electrostatic precipitators that work well for many different kinds of coal ash. In general, the low temperature electrostatic precipitator operated at about 423 K has been used for a long time but the electric resistivity of some kinds of coal ash is higher than appropriate for efficient operation of the electrostatic precipitator at this temperature [1]. As a means of compensating for the decrease of collection efficiency on high resistivity ash, two methods regulating the operating temperature of ESP have been proposed [2–4]. One method is to operate at higher temperature. This method decreases internal electric resistance and controls the resistivity of the ash. But this method has a problem in that the gas flow rate increases with the increase in gas temperature. The other method is to reduce the temperature under 373 K. This method reduces the surface electric resistance and improves the resistivity of the ash. In this case, however, the ESP is operated under the dew point, so corrosion is the main concern.

The influence of operating temperature and coal ash properties on collection efficiency of ESP was investigated using two types of experimental ESP equipment in pulverized coal combustion test facilities.

2. Experiment

2.1. Coal combustion test facility

In this research, two combustion test facilities were used to investigate the performance of ESP. The flow chart for each coal

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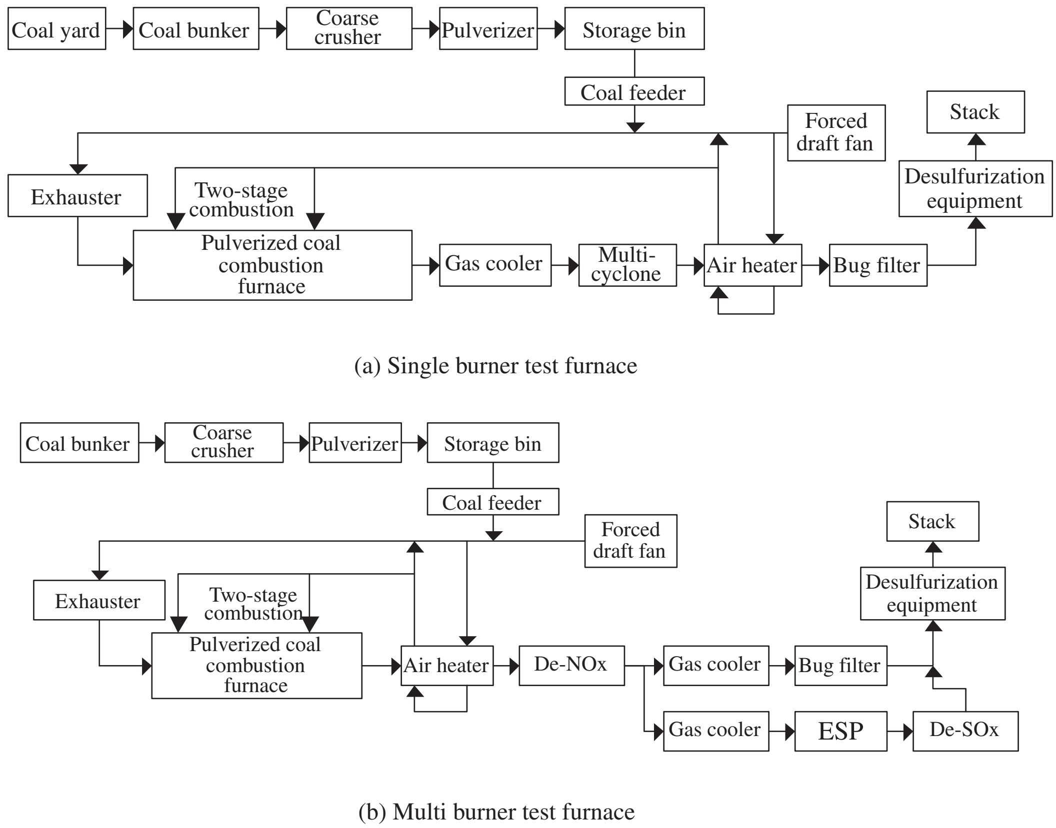

Fig. 1. Flow chart of the coal combustion test facilities.

combustion test facility is shown in Fig. 1. One facility has a single burner and the ESP inlet duct of this facility is connected to the furnace exit (high temperature gas) and the gas cooler exit (low temperature gas). The gas flow rate of this ESP is about 40% of the gas flow rate generated in the furnace. This ESP was installed to examine the performance of a high temperature ESP, and the operating temperature of this ESP can be controlled from 403 K to 623 K by mixing high temperature and low temperature gas.

The other furnace, which has three burners, was used to study the performance of an advanced low temperature ESP. In this multi burner test furnace, the combustion flue gas is separated after the De-NO*x* unit and sent to the ESP. The gas flow rate of this ESP is about 30% of the gas flow rate generated in the furnace. The operating temperatures of the ESP for this multi burner test furnace can be decreased from 473 K to 363 K using the gas controllers.

The coal feed rate is about 100 kg/h for the single burner test furnace and about 300 kg/h for the multi burner test furnace. The combustion condition in each furnace is the same. The residence time of the furnace is about 4 s. In these experiment, the excess O_2 concentration and the two-stage combustion ratio is set relatively at 4% and 30%.

2.2. Electrostatic precipitator

Table 1 shows the specification of the experimental ESP and the design value for the ESP of a pulverized coal combustion utility boiler in Japan [5]. The specification of the ESP is the same as for the utility boiler. The ESP of the multi burner test furnace has an intermittent charging system for high resistivity dust in addition to the conventional continuous charging system. The gas velocity was kept constant for all operating temperatures in the ESP by controlling the gas flow rate.

Table 1
Specification of ESP.

	Unit	Single burner test furnace	Multi burner test furnace	Utility boiler
Gas flow rate	m^3 N/h	280 (at 623 K)	1000 (at 403 K)	–
Operating temperature	K	403–623	363–473	363–623
Space between collection electrodes	mm	300	400	200–300
Gas velocity	m/s	0.84	0.39	0.6–2
Specific collection area (SCA)	s/m	109.9	75.5	80–150

2.3. Coal property

To investigate the influence of operating temperature on discharge characteristics and collection efficiency of ESP, Taiheiyou coal was used in the single burner test furnace and Hunter Valley coal was used in the multi burner test facility. Table 2 shows the properties of the main coals used these experiments. The ash concentration in each coal was 14.5 wt.% and 12.3 wt.%, respectively, so we took the particle concentration in the gas generated in the furnace as approximately the same.

3. Results and discussion

3.1. Particle concentration and size distribution of ESP inlet gas

The particle concentration and size distribution of the ESP inlet gas has a strong correlation with the collection performance of the ESP. The particle concentration at the ESP inlet was 4.30 g/m^3 N in