8.5 Air Pollutant Control Equipment

8.5.1 Overview

Testing methods of air pollution control equipment such as dust collector, desulfurization equipment, and denitrification equipment, and so forth, requires the technology to test for the design, maintenance, and capability guarantees, as well as being indispensable for research and development [1]. This explanation centers on JISB99909 [2], which stipulates expression of specification for dust collector, and JISB9910 [3], which stipulates method of measuring performance of dust elector.

8.5.2 Dust collector testing methods [1) 2) 3)]

(1) Expression of the Specification for dust collector [2]

Dust collector specifications are expressed, named, and modeled by 17 common items, and as specific items are cited as two items of gravity dust collector, four items of centrifugal force dust collector, five items of inertia dust collector, cleaning dust collector, and filtration dust collector each, and seven kinds of electrical dust collector. The examples most commonly cited are the common items and the specific items or centrifugal force (cyclone), cleaning (somber), filtration (bag filter), and electrical dust collector (electrostatic precipitator), which are in popular use.

(I) Common items

① Classification, ②Name and model, ③Application, ④Flow of dust collecting system, ⑤Raw gas flow, ⑥ Raw gas temperature, ⑦ Raw gas pressure, ⑧ Raw gas nature, ⑨ Nature of dust, ⑩ Dust concentration in inlet duct of dust collector, ⑪ Dust concentration in outlet dust, ⑫ Dust collecting rate (efficiency), ⑬ Pressure loss, ⑭ Dimensions, ⑮ Dust emission type,⑯ Thermal insulation, ⑰ Other.

(II) Specific items

① Cyclone force dust collector-i. Diameter that is basic for centrifugal force and fundamental gas velocity, ii. Cyclone step rate and number, iii. Presence or absence of a dust (particle) box.

② Scrubber-i. Kind of fluid (fresh water or sea water, or another type of fluid), ii. Fluid quantity (washing fluid quantity and pressure, additional fluid quantity and pressure, fluid holding quantity), iii. Fundamental gas velocity, iv. Gas/fluid separation method, v. Other.

③ Bag filter-i. Filter surface area and fundamental gas velocity, ii. Filter material (type, model, dimensions, number of bag cylinders, individual number, operating temperature range), iii. Shaking device, iv. Other

④ Electrical precipitator-i. Arrangement of collecting chambers, ii. Cross-sectional shape of collecting electrode, dimensions, number of ducts, duct pitch, iii. Cross-sectional shape of discharge electrodes, dimensions, number of electrodes, iv. Capacity of changing, number of equipment and changing system, rectification method, control method, hammering device, etc.

(2) Dust collector testing methods [1) 2) 3)]

(I) Test items

The test items of performance of dust collector are selected appropriately from the following items, having considered the test objectives.

① Raw gas temperature, pressure and composition in inlet and outlet dusts of ducts of dust collector, ② Raw gas flow, rate in inlet and outlet duct, ③ Pressure loss, ④ Dust concentration in the inlet and outlet ducts, ⑤ Dust flow rate in the inlet and outlet ducts, ⑥ Dust collection rate (efficiency) or penetration rate, ⑦ Specific gravity and particle diameter distribution of collected dust and dust in raw gasses within both the inlet and outlet ducts, ⑧ Apparent specific electric resistivity of same, ⑨ Water quantity used for dust collector and liquid gas ratio, ⑩ Waste water discharge quantity and quality, ⑪ Dust collector motive power consumption, ⑫ Noise of dust collector operation.

(II) Measuring methods and principles

The measurements for each performance test item are, as a rule, implemented during a stable period of operating conditions for both the dust collector itself and the air pollutant source installed dust collector. In this case, if there is a periodicity, the measurements are made across a lengthy period of time corresponding to one cycle. Moreover, as was described previously in (I) ①~⑦, subjects measured at the inlet and outlet ducts of dust collector have to be measured simultaneously, and the measuring positions within the duct and measuring points within the ducts cross-section are selected according to JISZ8808 regulations. In this case, the measuring position are selected as close to the dust collector unit itself as possible. Generally, the measuring position aims to be a position through which the gas flow within the duct can be regulated, and the principle is to avoid changes to the shape of duct cross section, but in maintaining the dust collecting efficiency such as in the bag filter and electrostatic precipitator, where it is necessary to regulate the flow of gas within the unit, it is possible to select a measuring position close to the unit itself. Further, in equipment that raw gas spins within the duct, such as cyclone, the ideal situation is to take measurements having installed a flow regulating gride within the duct. Moreover, details of these measuring methods are to be found in Chapter 8.1 and the related industrial standards (JISZ8808, JISB9910).

(III) Measuring methods of the temperature, static pressure and composition of raw gas in inlet and outlet ducts of dust collector

The temperature is measured using either an electrical thermometer or a glass envelope thermometer at each measuring point as described in Chapter 8.1, and prescribed by JISZ8808 [4]. Static pressure uses either a Pitot tube or a static pressure tube at each measuring point, and measurements conform either to JISZ8808, or to the methods described in Chapter 8.1. Moreover, in the case that static pressure measurement results in wall of duct obtained at static pressure pores installed right and left side on duct wall are equal, there is no objection to using the mean value as this measurement result. The Orsat analyzer is used for the gas composition, and the measurements conform either to JISZ8808, or to the methods described in Chapter 8.2.

(IV) Measuring methods of raw gas flow rate in the inlet and outlet ducts

The raw gas flow rate is measured by JISZ8808 or description in Chapter 8.1, using Pitot tube, or using an orifice, which is regulated by JISB8330. In this case, the gas flow rate can be expressed by wet gas flow rate at temperature and pressure within the inlet and outlet ducts, dry gas flow rate according to same condition, wet gas flow rate according to, temperature 0℃, pressure 1 atmosphere, dry gas flow rate according to same condition, wet gas flow rate according to specified condition, and dry gas flow rate according to same condition.

(V) Calculating methods of pressure loss

Pressure loss is expressed as the difference between the total mean pressure of the raw gas in the dust collector inlet and outlet ducts, and is calculated according to Eq. (1).

$$\Delta p = (p_{ti}) - (p_{to})$$

$$(p_{ti}) = \frac{p_{ti1} v_{ti1} + p_{ti2} V_{ti2} + \cdots\cdots + p_{tin} v_{tin}}{v_{ti1} + v_{ti2} + \cdots\cdots + v_{tin}} \quad \cdots\cdots (1)$$

$$(p_{to}) = \frac{p_{to1} v_{to1} + p_{to2} v_{to2} + \cdots\cdots + p_{ton} v_{ton}}{v_{to1} + v_{to2} + \cdots\cdots + v_{ton}}$$

Here, Δp : Pressure loss (mmAq or kgf/m^2)

(p_{ti}) : Total mean gas pressure in the inlet duct (mmAq or kgf/m^2)

(p_{to}) : Total mean gas pressure in the outlet duct (mmAq or kgf/m^2)

p_{ti1}、p_{ti2}・・・・p_{tin} : Total gas pressure at each measuring point in the inlet duct (mmAq or kgf/m^2)

v_{ti1}、v_{ti2}・・・・v_{tin} :Gas velocity each measuring point in the inlet duct (m/sec)

p_{to1}、p_{to2}・・・・p_{ton}: Total gas pressure at each measuring point in the outlet duct (mmAq or kgf/m^2)

v_{to1}、v_{to2}・・・・v_{ton} : Gas velocity each measuring point in the outlet duct (m/sec)

(VI) Measuring methods of dust collection and dust flow rate inlet and outlet ducts of dust collector

These measurements are prescribed by JISZ8808 or described in Chapter 8.1. In this case, the dust concentration, in the bag filter outlet, is measured using a high volume air sampler in equipment that is not equipped with an outlet duct, such as an open model beg filter. In this case, the raw gas flow rate necessary for calculating the dust flow rate determines the blown up area measured using a portable fan anemometer, which measures the mean gas flow speed of the area blown up within the equipment.

(VII) Calculation methods of dust collection rate (efficiency) or dust penetration ratio of dust collector

① Determing method from dust flow rate within the inlet and outlet ducts

The dust collection rate (efficiency) is calculated using Eq. (2). Moreover, when $Q_o = Q_i$, Eq. (3) can be used.

$$\eta = (1 - \frac{S_o}{S_i}) \times 100 = (1 - \frac{C_o Q_o}{C_i Q_i}) \times 100 \quad \cdots\cdots (2)$$

$$\eta = (1 - \frac{C_o}{C_i}) \times 100 \quad \cdots\cdots (3)$$

② Determing method from dust flow rate within the inlet duct and collecting dust quantities per unit time in the dust box

In this case, the dust collection rate (efficiency) is calculated using Eq. (4).

$$\eta = (1 - \frac{S_c}{S_i}) \times 100 \quad \cdots\cdots (4)$$

③ Determing method from dust flow rate within the outlet duct and collecting dust quantities per unit time

In this case, the dust collection rate (efficiency) is calculated using Eq. (5).

$$\eta = (1 - \frac{S_c}{[S_c + S_o]}) \times 100 \quad \cdots\cdots (5)$$

④ Penetration rate of dust collector is calculated using Eq. (6).

$$p = 100 - \eta \quad \cdots\cdots (6)$$

Here, η ; Dust collection rate (efficiency) (%)

S_o ; Dust flow rate within the outlet duct (kg/h)

S_i ; Dust flow rate within the inlet duct (kg/h)

S_c ; Quantity of collecting dust per hour in the dust box (kg/h)

C_o ; Dust concentration in the outlet duct (g/m^3, g/m_N^3)

C_i ; Dust concentration in the inlet duct (g/m^3, g/m_N^3)

Q_o ; Gas flow rate within the outlet duct (m^3/h, m_N^3/h)

Q_i ; Gas flow rate within the inlet duct (m^3/h, m_N^3/h)

p ; Penetration rate (%)

(VIII) Measuring method of quantity of collecting dust per hour in dust box

The quantity of collecting dust and the collecting time are measured, and calculated using Eq.(7).

$$S_c = \frac{M}{t} \quad \cdots\cdots (7)$$

Here, M =Amount of collecting dust by dust collector during whole time of dust sampling in the duct (kg).

t = Operating time of dust collector during whole sampling time in duct (h).

(IX) Measuring method of the apparent specific electric resistivity, particle diameter distribution, and specific gravity of the dust sample in the dust collector

The specific gravity for the collecting dust and the dust within the inlet and outlet ducts of the dust collector is measured using either JISZ8807 specifications, or a air comparison type pycnometer. And the particle diameter distribution is measured using either a siering method prescribed by JISZ8801, or a sedimentation method or microscope method prescribed by JISZ8901 and JISA1204, and is expressed as a mass basis. Moreover, the apparent electric resistivity is measured using either a paralleled disk electrode, needle-disk electrode, coaxial-cylinder

electrode and pectinated electrode method.

(X) Measuring method of quantity of used water and discharged water

The used water quantity and the discharged water quantity are both measured using either a float type area flow meter as prescribed by JISZ8761, a throtting flow meter prescribed by JISZ8762, a Venturi tube type flow meter as prescribed by JISZ8763, or by Wein, as prescribed by JISK0102.

And liquid gas ratio is calculated by Eq.(8)

Water quality is analyzed by JISK0102.

$$L = \frac{q_w}{Q_i} \qquad \cdots\cdots (8)$$

Here, L = Liquid gas ratio (ℓ /m^3)

q_w = Used water flow rate (ℓ /h)

Q_i = Wet gas flow rate in the inlet duct of dust collector (m^3/h)

(XI) Measuring method of power consumption of dust collector

① Power consumption due to pressure loss can be obtained using Eq.(9)

$$P = 0.273 \times 10^5 \Delta p Q_i \qquad \cdots\cdots (9)$$

Here, P = Power consumption (kw)

② Power consumption of fan motors, motors equipped in dust collector and so forth is measured by integrated. The dust collector noise is measured using JISZ8731 regulations. Moreover, the measurement method of fan noise is prescribed by JISB8330.

8.5.3 Desulfurization and denifitrification equipment for flue gas testing method

These are the same as for the dust collector test methods cited previously. In this case, the concentration of dust, including within both the inlet and outlet ducts, are designated as sulfur oxides concentrations and nitrogen oxides concentrations respectively. And in the case of the desulfurization equipment, the collecting dust quantity can regard as the quantity of by-product gypsum. Further, an equipment flow sheet based on the dust collecting system is also necessary.