Recent Technology of Moving Electrode Electrostatic Precipitator

Hiroki Ando
Hitachi Plant Technologies, Ltd.
Japan
hiroki.ando.xe@hitachi-pt.com

Nobuhiko Shiromaru
Hitachi Plant Technologies, Ltd.
Japan
nobuhiko.shiromaru.cw@hitachi-pt.com

Yoshihiko Mochizuki
Hitachi Plant Technologies, Ltd.
Japan
yoshihiko.mochizuki.jy@hitachi-pt.com

1 Summary / Abstract:

In China and India which are achieving strong economic growth, air pollution caused by emissions from coal-fired power plants and steel plants is a serious problem and therefore these countries are rapidly tightening their emission standards. Since these emerging countries have abundant coal resources, coal is expected to account for a majority of their energy resources and it is therefore imperative for them to install flue-gas treatment equipment for their existing coal-fired power plants and steel plants as well as new ones. Our Moving Electrode Electrostatic Precipitator (MEEP) with its unique technology offers superior collection of highly resistive dust such as coal ash and sintered ash and we will enter the market with this core technology. This technical report describes our development of the new MEEP, which substantially reduces the dust-collection area and facilitates maintenance, to reduce cost and maintenance work.

2 Introduction

In developing countries such as China and India which are achieving strong economic growth, power plants and iron mills are being constructed in rapid succession to meet the rising demand for electric power, iron and steel.[1)2)] Since these countries have abundant coal resources, they are heavily dependent on coal for energy; China and India are expected to account for 46% and 21%, respectively of total world coal consumption in the long term.[3)] However, air pollution caused by smoke emitted from coal-fired power plants and iron mills is a serious problem. Therefore, many countries are tightening emission standards, small old power plants are being converted into new large ones, and various flue-gas treatment equipment is being installed. To meet the need for precipitators in these countries, we will enter the market with our moving-electrode electrostatic precipitator (MEEP) as a key technology. This report introduces the MEEP designed for developing countries.

3 Present status of MEEP and development concept

3.1 Dust collection performance of MEEP

The dust collection ratio η is expressed as the ratio of the reduced dust concentration at the precipitator outlet to the dust concentration at the inlet, and is calculated by Matts' formula:

$$\eta = \left[1 - \exp\left\{ - (\omega_k \cdot A/Q)^N \right\} \right] \times 100\,[\%]$$

A is the dust collection area, Q is the inflow gas amount and ω_k is the particle moving velocity, which is the velocity of dust particles moving toward the dust-collecting electrode in the discharge space. ω_k is an index of how easily dust can be collected, namely the dust-collecting performance of a precipitator, which closely depends on electrical resistivity. Dust such as low-sulfur coal combustion ash and steel sinter having high electrical resistivity strongly adheres to the electrode plate due to electrification, and this accumulated dust causes an extraordinary discharge called back corona, substantially reducing ω_k, namely the dust-collecting performance in general fixed electrodes (Fig. 1).

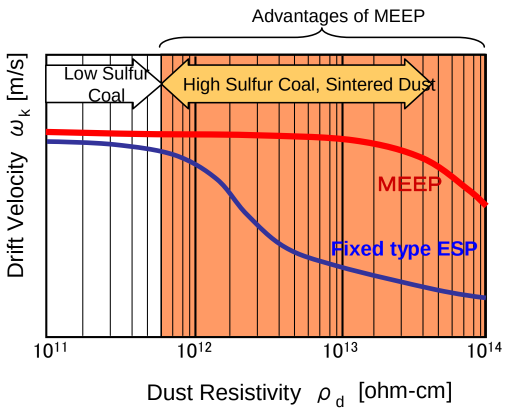

Fig. 1: Relation between dust resistivity and particle drift velocity

On the other hand, in the MEEP, the moving electrode plate collects dust and the rotary brush within the lower hopper removes dust from the electrode surface. Therefore, the MEEP can effectively collect highly-resistive dust, which cannot be removed by the hammering method in general fixed electrodes, as well as the fine dust which drifts in with the gas flow again in the hammering method. As a result, the dust collection area can be reduced substantially (Fig. 2).

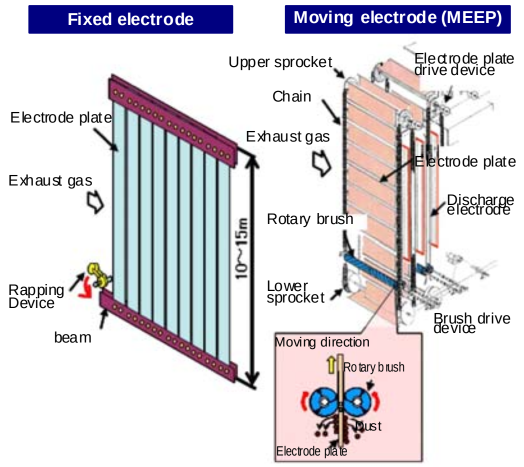

Fig. 2: Structural comparison of the fixed electrode and the moving electrode

However, parts such as the chain and sprocket which move the electrode are exposed to a severely dusty environment. Therefore, the present MEEP must be installed in an environment where the dust concentration is less than 1 g/m^3_N to prolong its life. At present, the fixed electrode (section 1-2) is installed upstream of the precipitator where the dust concentration is high and a MEEP is installed downstream of the precipitator. In this configuration, the dust collection area is reduced by about 20% compared with the fixed electrode configuration.

3.2 Development concept and target specifications

In Japan, dust concentration at the precipitator inlet is typically 1 - 2 g/m^3_N for steel sinter and about 20 g/m^3_N for coal-fired thermal power. However, it is about 80 g/m^3_N for Indian coal and so a larger dust collection area is required. If the allowable dust concentration for MEEP is improved, the ratio of MEEP's dust collection area is increased, the total dust-collecting is reduced substantially and the equipment can be made more compact. Therefore, in developing countries, MEEP can be installed when replacing existing equipment without changing its footprint to increase the dust-collecting performance and meet the standards. As a result, the use of steel materials for casing and the total cost can be reduced substantially.

This development study focuses on modifying the present MEEP to operate in highly dusty environments and to downsize the equipment. Our target specifications are shown in Table 2.

Table 1: Development subjects and target specifications

	Effect	Development subject	Target specifications	Verification method
Abrasion-resistant chain	High resistance against high dust concentration	Selection of material	Operation in dust concentration of 3 g/m^3_N Life span of 4 years or more	Abrasion test
		Assessment of life span		
Simplification of brush structure	High resistance against high dust concentration Reduction of maintenance work	Assessment of dust-removing performance	Remaining dust thickness of 20 μm or less	Continuous dust removal test
		Assessment of life span	Life span of 4 years or more	
Verification of dust-collecting performance	High resistance against high dust concentration Optimal size of equipment	Performance comparison	40% reduction of dust-collection area	Test of pilot precipitator
		To find optimal conditions		

4 Study of MEEP that can operate at high dust concentrations

This section introduces part of our development study. Sintered ash and coal ash (fly ash) are used for the respective tests because they are different in density, particle size distribution and hardness.

4.1 Abrasion resistance assessment of chains for the MEEP drive

Link chains and roller chains can be used for the connection and drive of MEEP, but roller chains are used today because they absorb less dust and are highly abrasion-resistant. Abrasion of the roller chain is caused mainly by friction between the pin and the bushing in the connecting section, and abrasive wear such as scratch marks occurs when dust enters between them and the chain is extended as abrasive wear progresses.

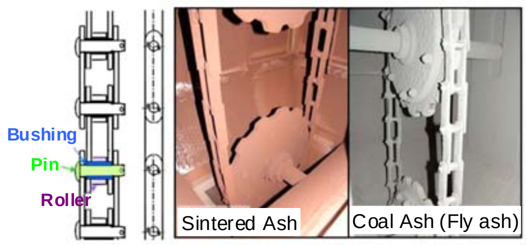

Fig. 3: Chain structure and abrasion test status

When assessing the abrasion resistance of a chain, dust is accumulated on a chain by electrostatic adhesion caused by discharge in a dusty atmosphere of 3 g/m^3_N as a target value, and continuous operation equivalent to 10 years is performed while applying tensile force required to operate actual equipment, and the extension of the chain is measured as needed (Fig. 3).

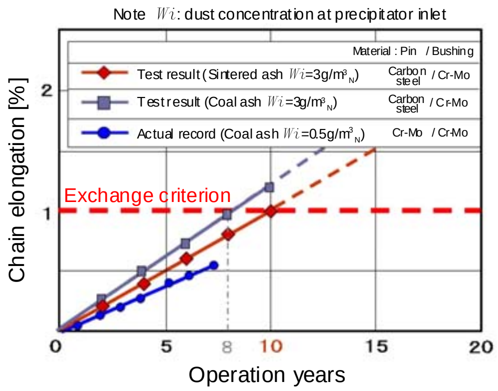

Fig. 4: Life of chain (Abrasion test result)

Part of the test results is shown in Fig. 4. The chain life is 10 years for sintered ash and about 8 years for coal ash, satisfying the target life of 4 years.

In addition, to select the optimal material, we compared low-hardness carbon steel, medium-hardness Cr-Mo alloy steel which is the conventional material, and high-hardness Ni-Cr-Mo steel used for pins and bushings, and found that the combination of carbon steel pin and Cr-Mo bushing can be used as effectively as the conventional material. This fact coincides with the tendency that when two materials of different hardness are combined, abrasion between them is less, as reported in many research papers on abrasion. In addition, compared with past records, the chain did not extend so much even though the dust concentration was higher. We consider that this is because the amount of dust entering inside the chain, which is the main cause of abrasion, is not so closely related to the concentration of dust in the environment.

4.2 Simplification of dust removal brush

In the present MEEP, two rotary brushes move on the electrode between them to remove dust forcibly. Although dust can be removed effectively, the brushes wear out easily and so the contact must be adjusted every 2 years.

Our experiments have identified the maximum dust layer where back corona does not occur in the dust-collecting electrode and we have developed a simple fixed brush having sufficient performance to remove dust. First, the experiments clarified that the target remaining dust layer thickness is 20 μm,

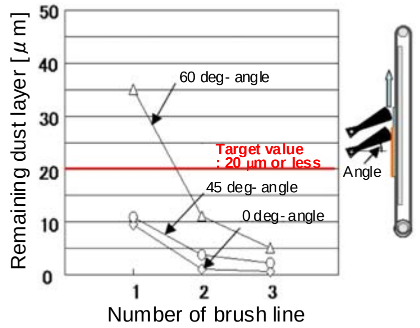

Fig. 5: Results of basic study on fixed brush

and we then studied the brushing conditions to give the required dust removal performance in order to satisfy that target. As a result, we confirmed that a one-stage brush can remove dust sufficiently if it is set at an angle of 45 degrees or less from the horizontal (Fig. 5). By using a small-scale test MEEP, we conducted a continuous operation test and confirmed that the new brush system has long-term operational stability and a lifespan of 4 years or more (Fig. 6). The new brush can be disassembled into small parts and thus replaced easily within the narrow precipitator.

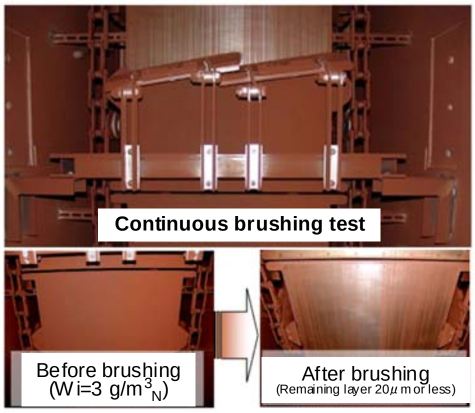

Fig. 6: Continuous brushing test

4.3 Performance assessment of MEEP at high dust concentrations

We conducted a dust collection test with the pilot precipitator capable of treating gas of 2,400 m^3_N to assess the performance of MEEP at high dust concentrations (Fig. 7).

The pilot precipitator consists of two MEEP sections and by stopping the movement of the MEEPs, we can simulate operation of a fixed electrode. For the gas flowing into the precipitator, external air is heated by an oil burner, moisture is adjusted and dust is supplied by a micro-feeder in the specified quantity.

Fig. 7: Pilot ESP (for performance test)

Inlet dust concentration (Wi), dust resistivity (ρ_d) and charging current conditions were converted into the parameters in the test and amount of dust was measured before and after the electrical precipitator to check its performance.
Under the conditions of Wi = 3.0 g/m^3_N, outlet dust concentration Wo = 0.05 g/m^3_N (dust collection ratio η = 98.3%) and P = 1.0 × 10^{13} ohm-cm, the MEEP and the fixed electrode were tested, and the sizes of the precipitator were assessed based on the results (Fig. 8).

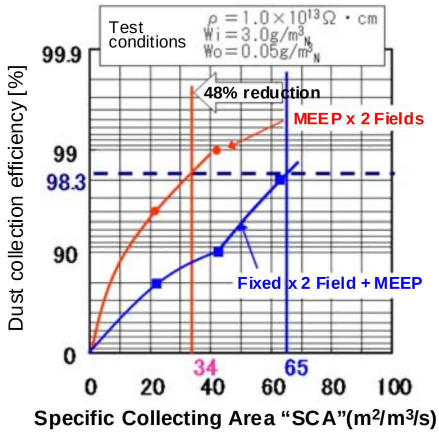

Fig. 8: Example of ESP size evaluation

SCA is the dust collection area divided by the incoming gas amount and is an index of the volume of a precipitator. The figure clearly shows that, in the case of highly resistant dust of 1.0 × 10^{13} ohm-cm, the configuration of MEEP + MEEP reduces the collection area by as much as 48% compared with our conventional configuration of fixed electrode + MEEP.

5 Results of development

As an example of successful development, we introduce the MEEP structure for sinter plants (Fig. 9). The equipment consists of two areas, using only MEEPs, simplified brushes and a high-frequency high-voltage power supply. In our test design, the equipment volume is almost half that of our conventional product and so its installation space and total mass are reduced. Since several types of power source and brush mechanism are prepared, users can select the best combination to meet their specific needs such as cost, performance and installation space.

6 Conclusion

We have already delivered our precipitator to a steel plant in Taiwan and provided technical assistance to a precipitator manufacturer in China. We will further promote MEEP overseas based on this development result. This technology will satisfy the need to upgrade performance and modify the conventional installation in Japan as well as overseas. We will continue to develop precipitators that satisfy various needs.

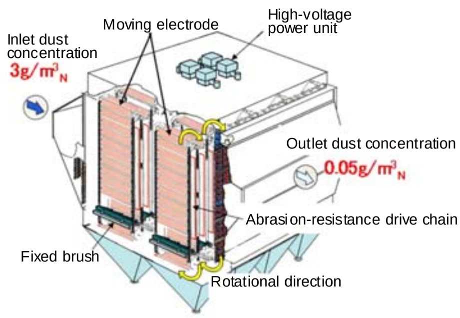

Fig. 9: 2 Fields MEEP for sinter plant

(“MEEP” is the trademark of Hitachi Plant Technologies, Ltd.)

7 Literature

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