Recent Application and Running Cost of Moving Electrode type Electrostatic Precipitator

Toshiaki Misaka, Yoshihiko, Mochizuki
(Hitachi Plant Technologies, Co. Ltd. 4-5-2 Higashi-Ikebukuro, Toshima-ku, Tokyo, 170-8466, JAPAN
E-mail: toshiaki.misaka.sn@hitachi-pt.com)

Abstract: Advantages of a moving electrode type electro-static precipitator (ESP) and the present supply record are described briefly. The latest gas treatment system for a coal fire power station consists of a moving electrode type ESP, a $DeSO_x$ system and a wet ESP in Japan. The gas temperature of the moving electrode type ESP is 80 deg-90 deg. Celsius. This system can reduce outlet dust concentration to less than 1 mg/m^3N and outlet sulfuric acid mist to less than 0.1 ppm. The running cost of a moving electrode type ESP was studied using actual operation results. Maintenance and repair cost of a moving electrode type ESP accounts for 10%-12% of the running cost. That is almost the same as the maintenance and repair cost of a fixed electrode type ESP. The total cost of the moving electrode type ESP including facility and running cost is cost effective compared to a fixed electrode type ESP.

Keywords: Electrostatic precipitator, moving electrode, SO_3, CO_2 capture, running cost

1 INTRODUCTION

Recently, global concern about air pollution control has been increasing. In the United States of America, a new regulation (Clean Air Act) was implemented and the sulfuric acid concentration of power plant boiler gas became much stricter in 2005.

In Europe, installation of a separate and recovery system of carbon dioxide (CO_2) from a coal fired power plant boiler will be required in 2020. The CO_2 capture system requires extremely low level dust concentration for a gas cleaning system.

Air pollution is a serious problem in China [1] and India[2] with rapid industrial growth and the demand for electrostatic precipitators (ESP) is increasing. In Japan, high efficient gas treatment system for thermal power plants are required to achieve very low particulate and sulfuric acid emissions as well as to maintain very low visible opacity.

Hitachi Plant Technologies developed a moving electrode system for ESP in 1979 that prevents back corona by removing the collected dust using rotating brushes and movable collecting plates. The moving electrode system is effective to collect high resistivity dust and can perform high collection efficiency. It is compact compared with a conventional fixed electrode system and can also reduce electrical power consumption [3, 4].

This paper briefly describes applications of a moving electrode type ESP and its running cost such as maintenance, repair and utility cost.

2 MOVING ELECTRODE TYPE ESP

Fig. 1 shows the illustrated composition of a moving electrode type ESP. The first and second sections at the gas inlet side are a fixed electrode system and the outlet side section is a moving electrode system.

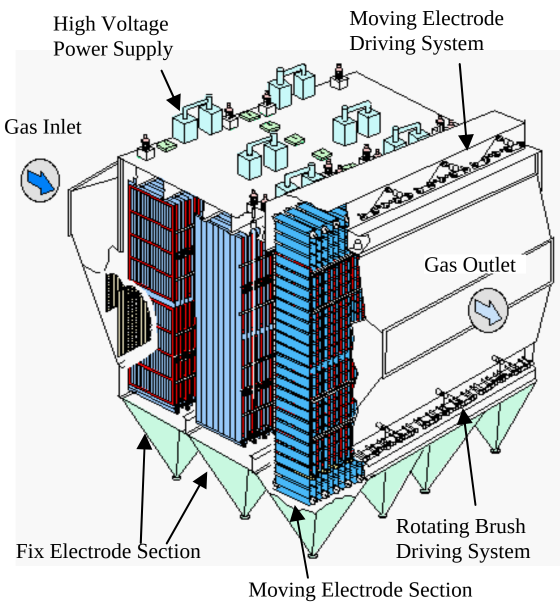

Fig. 1 Overall structure of Moving Electrode Type Electrostatic Precipitator (MEEP)

Fig. 2 shows the details of a moving electrode system. The collecting plates of the moving electrode system are divided into strips, coupled with chains and move slowly by driving wheels. The discharge electrodes are installed between collecting plates at the collection zone. Dust is collected to the collecting plates by electrostatic force as treatment gas flows through the collection zone. Collected dust attached to the collecting plate is transferred to the hopper before the dust layer becomes thick enough to cause back corona.

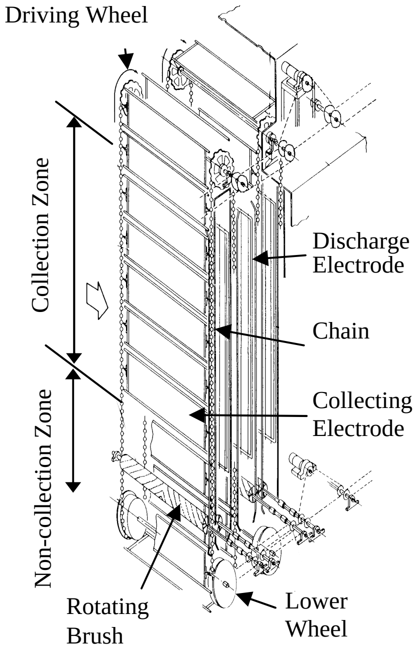

Fig. 2 Structure of Moving Electrode System

The moving electrode system is equipped with brushes that sweep off dust from the movable collecting plate. Rotating brushes for dust removal are installed in the hopper. This area is a non-collection zone which is free from gas flow or electricity. The collected dust is completely removed by rotating brushes, thus the collecting plates are kept clean at all times. In addition rapping reentrainmet can not occur by brushing.

This system maintains stable collection efficiency even when treating gas containing high resistivity dust, which can not be performed with stability by using a conventional fixed electrode type ESP because of the high resistivity dust problem. Table 1 shows the comparison between a conventional fixed electrode type ESP and a moving electrode type ESP based on 1000 MW coal fired boiler.

Table 1 Comparison Between Fixed Electrode Type ESP and Moving Electrode Type ESP Based on 1000 MW Coal Fired Boiler

Item	Fixed Electrode Type ESP	Moving Electrode Type ESP
No. of Field	4 (Fixed 4)	3 (Fixed2+Moving1)
Unit's Footprint	(100%)	(74%)
Weight	(100%)	(71%)
Power Consumption	(100%)	(67%)
Outlet Dust Density	30 mg/m^{3}N	30 mg/m^{3}N

The moving electrode type ESP has various advantages compared to the fixed electrode type ESP. It can decrease power consumption to 67% and the installation area to 74%. Users of a moving electrode type ESP can reduce such cost as land, foundation and running. The reliability of a moving electrode type ESP has been proved over a long period of time through many applications.

In case of retrofit of an existing ESP, since a moving electrode type ESP is smaller than a fixed electrode type ESP, the requirement of higher performance can easily be met by adding the moving electrode type ESP in the area where the existing fixed electrode type ESP has been installed.

3 RECENT APPLICATION OF MOVING ELECTRODE TYPE ESP

3.1 Supply Record

Table 2 shows the latest supply record of the moving electrode type ESP. A total of 57 units have been supplied to date. Four new units are now under construction. The application covers a wide variety of fields.

Table 2 Supply Record of Moving Electrode Type ESP

Application	Quantity
Coal Fired Boiler	33
Sintering Machine	12
Cement Kiln	2
Glass Melting Furnace	2
Fluidized Catalysis Cracker	2
Others	6
Total	57

There is an increasing demand in the use of the moving electrode type ESP for coal fired boilers as large amounts of exhaust gas must be treated and outlet dust concentration becomes strictly regulated. Another increasing application is for sintering machine exhaust gas in iron works because the conventional fixed electrode type ESP can not maintain stable collection efficiency due to high resistivity dust problem.

3.2 Application in China

Until now, a moving electrode type ESP has mainly been supplied in Japan. We are now responding to various inquiries from foreign countries.

In China, we supplied a moving electrode type ESP for the No. 5 coal fired boiler of Changzhou Guangyuan Cogeneration Co., Ltd in 2006. Fig. 3 shows the unit. The ESP consists of two fixed electrode sections designed by Enelco Environment Technology Co. in China and one moving electrode section designed by Hitachi Plant Technologies Ltd.

The measured performance data of this unit is shown in Table 3. The second unit of a moving electrode type ESP for the No. 6 boiler has now started operation at the same site.

Another application of a moving electrode type ESP is for a sintering machine in an iron making factory which is now under construction. It is designed to treat gas volume of 390,000 m^3/h and outlet dust concentration of 30 mg/m^{3}N.

Fig. 3 Changzhou Guangyuan Cogeneration Co., Ltd. Moving Electrode Type ESP for CFB No. 5 Boiler

Table 3 Performance Data of Changzhou ESP

Item		Design	Actual
Gas Volume	m^3N/h	120000	107000
Gas Temperature	deg. C	145	110
Inlet Dust Density	g/m^3N	25.0	23.1
Outlet Dust Density	g/m^3N	0.050	0.021
Collection Efficiency	%	99.80	99.89
Dust Resistivity	ohm-cm	1×10^{13}	6×10^{12}

4 MODERN GAS TREATMENT SYSTEM FOR COAL FIRED BOILER

With increasing concerns about air pollution, a high efficient gas treatment system for power plants has been developed to achieve very low particulate and sulfuric acid mist emissions as well as to maintain very low visible opacity in Japan.

Fig. 4 shows the modern gas treatment system and conventional system for 1000 MW coal fired boiler. This modern system, the latest technology, consists of a DeNOx system, a dry ESP (DESP), a $DeSO_x$ system, a wet ESP (WESP) and a GGH (Gas-Gas Heater). The GGH consists of a heat recovery section and a reheat section.

The main difference between the modern system and the conventional system is the gas temperature of the DESP (dry ESP). With the conventional system, a DESP is installed at the down stream of an air heater (A/H) and the gas temperature is 130 deg-150 deg. Celsius. This DESP is called a cold side ESP.

On the other hand with the modern system, a DESP is installed at the down stream of a heat recovery section of GGH and the gas temperature is 80 deg-90 deg. Celsius. This DESP is called a low temperature ESP.

The modern system has two advantages. This system collects the dust highly efficiently at the low temperature ESP and the sulfuric acid mist as well which is changed from sulfuric acid gas at GGH (heat recovery section). This is due to the fact that the gas temperature of the low temperature ESP is low.

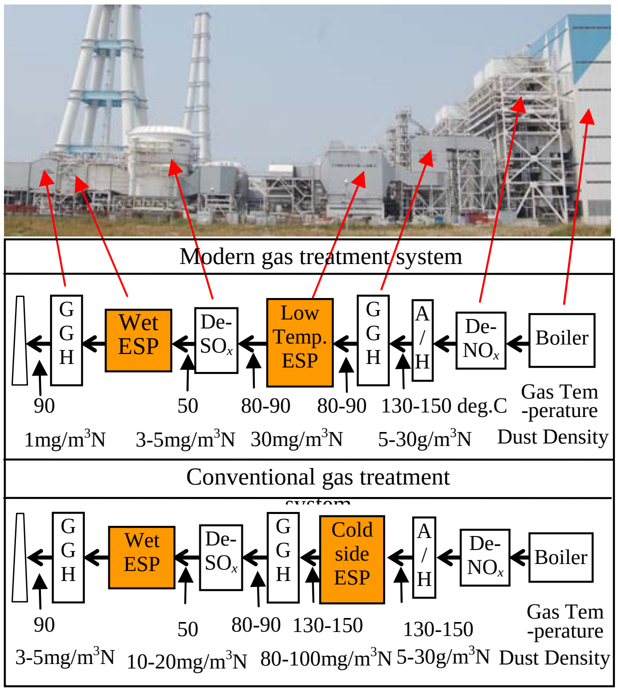

Fig. 4 Gas treatment system in Japan

4.1 Dust Collection

Dust from a coal fired boiler is collected by the DESP and the WESP. The $DeSO_x$ system can collect dust subsidiarily.

For the conventional system, the outlet dust concentration of DESP is designed by 80 mg/m^3N -100 mg/m^3N in order to protect the GGH from corrosion. The limit of outlet dust concentration is, therefore, set at 3 mg/m^3N -5 mg/m^3N.

On the other hand, in the case of the modern system, GGH (heat recovery section) is installed at the upstream of the DESP, and the outlet dust concentration of the DESP can be reduced and is required to be less than 30 mg/m^3N before $DeSO_x$ system to improve the quality of gypsum.

This low temperature ESP has advantages. Collection efficiency of the DESP improves due to the decrease of both the dust resistivity and the treated gas volume because the gas temperature is low. However, reentrainment of collected dust occurs strongly and the outlet dust concentration increases compared to the cold side ESP because of the rapping of collecting plates.

Moving electrode type ESP is therefore applied to this system because of such advantages as stable high collection efficiency and no rapping entrainment. With our experience, it is possible to design the outlet dust concentration of moving electrode type ESP in less than 10 mg/m^3N.

The WESP, which is installed at the down stream of DeSOx system, removes fine particle, carried over mist and a little sulfuric acid mist from the $DeSO_x$ system. Measured performance data of the modern system is shown in Table 4. The values of the outlet dust concentration of the WESP are 0.32 mg/m^3N to 1.0 mg/m^3N.

Table 4 Performance Data of Moving Electrode Type ESP on Modern Gas Treatment System

		Design	Actual	Actual	Actual	Actual
Output Power	MW	1000	1000	1000	1000	1000
Coal		A	C	D	E	C
Gas Volume	m^3N/h	2949200	3081070	3087000	3149100	3136500
Gas Temperature	deg.C	90	93	87.4	91.0	85
Inlet Dust Density	g/m^3N	22.00	7.808	9.033	4.850	5.842
Outlet Dust Density	g/m^3N	0.030	0.0194	0.022	0.0110	0.0090
Collection Efficiency	%	99.80	99.75	99.76	99.24	99.85
Dust Resistivity	ohm-cm	1.1×10^{12}	1.7×10^{12}	1.5×10^{12}	1.4×10^{12}	1.6×10^{12}
Coal		B	C	D	E	C
Gas Volume	m^3N/h	3116500	3273000	3103000	3170700	3139300
Gas Temperature	deg.C		54	49	54	50
Inlet Dust Density	g/m^3N	0.005	0.0018	0.0034	0.0010	0.0025
Outlet Dust Density	g/m^3N	0.0035	0.00061	0.001	0.00032	0.0006
Collection Efficiency	%	30	66.1	70.6	68.0	76.0

In Europe, CO_2 capture system requires that the value of low dust concentration becomes less than 1 mg/m^3N. With this modern system, the requirement of the low dust concentration can easily be met.

4.2 Sulfuric Acid Mist Collection

Fig.5 shows the conceptual diagram of sulfuric acid mist concentration at the modern gas treatment system and the conventional gas treatment system for coal fired boiler.

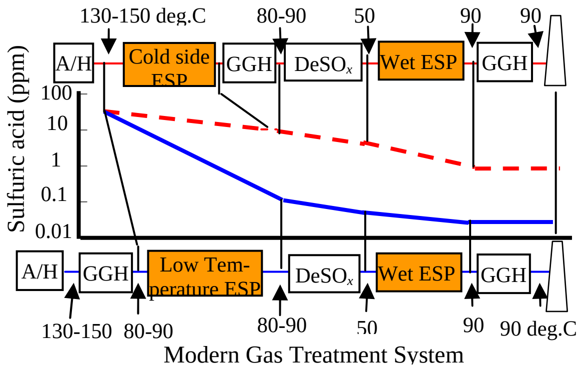

Fig. 5 Change of Sulfuric Acid Concentration in Gas Treatment System

Sulfer in coal generates sulfur dioxide gas (SO_2) by combustion of boiler. Some SO_2 converts into sulfuric acid gas (SO_3) by the catalytic action of a boiler and a $DeNO_x$ system. As gas temperature decreases, SO_3 gas gets combined with the moisture and changes to sulfuric acid (H_2SO_4) gas and mist.

The relationship between H_2SO_4 gas concentration and dewpoint is shown in Fig. 6 which was calculated using Muller formula [5]. In the case of the conventional gas treatment system, the gas temperature of the cold side ESP is 130 deg-150 deg. Celsius. According to Fig. 6, if H_2SO_4 gas concentration is over 70 ppm, H_2SO_4 will be condensed and will generate H_2SO_4 mist can be collected by DESP. Almost 70 ppm H_2SO_4 gas passes through the DESP and discharges from the chimney directly. The exhaust H_2SO_4 gas forms blue plume.

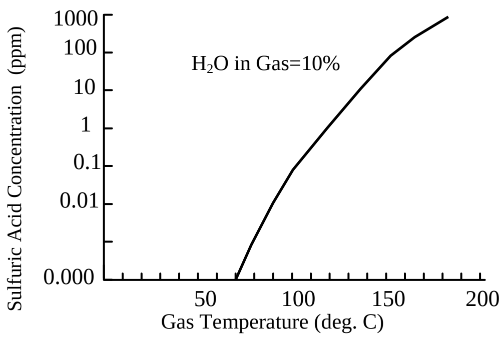

Fig. 6 Dew Point vs. Concentration of Sulfuric Acid

When the $DeSO_x$ system is provided at the exit of the cold side ESP in the conventional system, a lot of fine H_2SO_4 mist generates since gas temperature falls rapidly in the $DeSO_x$ system. This fine H_2SO_4 mist, which is submicron particle, is difficult to be removed because the mist cannot collide with the spray of the $DeSO_x$ system. To solve this problem, it is necessary to build a large size WESP to collect fine H_2SO_4 mist.

As for the modern system, gas temperature of the low temperature ESP decreases to 80 deg-90 deg. Celsius. At this temperature, most of H_2SO_4 gas changes to H_2SO_4 mist at GGH heat recovery section and is collected together with dust easily at the DESP. In this case, the WESP mainly collects fine particle and the carried over mist from the $DeSO_x$ system. Therefore, it is sufficient enough to apply a smaller size WESP to clean up exhaust gas.

Measured H_2SO_4 concentration at the outlet of the moving electrode type ESP in the modern system is 0.33 ppm and outlet of the WESP is less than 0.1 ppm. This system fully satisfies the severe exhaust gas conditions of the power companies in Japan.

5 RUNNING COST OF MOVING ELECTRODE TYPE ESP

The total cost of ESP consists of the initial cost and the running cost. The initial cost consists of the cost of the facility, foundation work and land cost. The running cost consists of maintenance, repair and utility cost.

Cost comparison of a moving electrode type ESP and a conventional fixed electrode type ESP was studied using actual operation results. One experimental result is shown in Figs. 7 and 8.

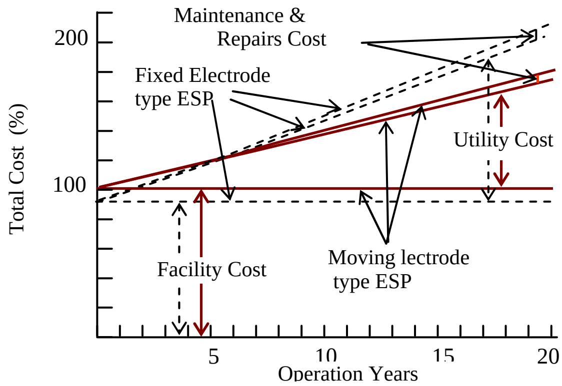

Fig. 7 Total Cost and Operation Years

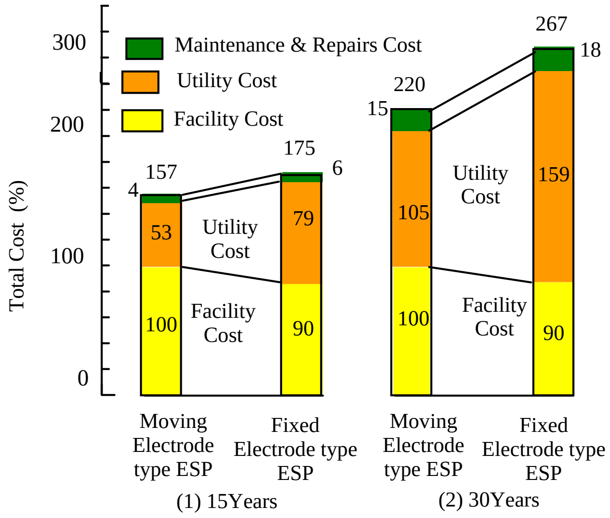

Fig. 8 Total cost for 15 Years and for 30 Years

In the case of the fixed electrode type ESP, the total running cost over a span of 15 years becomes almost the same as that of the facility cost.

Approximately 90% of the running cost ac-counts for the utility cost. Most of the utility is used for the electric power consumption of high voltage power supplied to the ESP. The moving electrode type ESP operates with less than 70% power consumption of the fixed electrode type ESP.

The maintenance and repair cost accounts for 7%-12% of the running cost. The maintenance and repair cost of the moving electrode type ESP is almost the same as the fixed electrode type ESP.

The running cost of the moving electrode type ESP is almost 68% that of the fixed electrode type ESP. This explains that the moving electrode type ESP has an advantage over the fixed electrode type ESP.

Generally, the facility cost of the moving electrode type ESP and the fixed electrode type ESP are the same if the collection efficiency and high resistivity dust collection are attained and maintained in the same manner. Although the case may be such, given the condition that the facility cost of a fixed electrode type ESP is initially cheaper by 10% compared to the moving electrode type ESP, the total cost including facility and running cost will, however, becomes the same as that of the moving electrode type ESP in 5 years as shown in Fig.7. In 15 years, the total cost for the fixed electrode type ESP increases by 20% or more than that of the moving electrode type ESP as shown in Fig. 8.

The moving electrode type ESP has economical advantage over the fixed electrode type ESP considering the cost of the land and foundation work.

6 CONCLUSIONS

(1) A total of 57 units of the moving electrode type ESPs have been used in a wide variety of the industrial fields. There is an increasing demand for the moving electrode type ESP for coal fired boilers and sintering machines. These applications are difficult for the conventional fixed electrode type ESP due to high resistivity dust problem.

(2) Until now, a moving electrode type ESP has mainly been supplied in Japan. We are now responding to various inquiries from foreign countries. The moving electrode type ESP has already been supplied in China.

(3) The latest gas treatment system for coal fire power station consists of a moving electrode type ESP, a $DeSO_x$ system and a wet ESP in Japan. The gas temperature of a moving electrode type ESP is 80 deg-90 deg. Celsius. This system can reduce outlet dust concentration to less than 1 mg/m^3N and outlet sulfuric acid mist to less than 0.1 ppm.

(4) The running cost of the moving electrode type ESP is almost 68% that of the fixed electrode type ESP. The maintenance and repair cost of a moving electrode type ESP is 10%-12% of the operation cost and almost the same as a fixed electrode type ESP.

(5) The total cost of the moving electrode type ESP including facility and running cost is inexpensive compared with the fixed electrode type ESP.

REFERENCES

1. Chinese Society of Electrostatic Precipitation. Proceedings of The 11th Conference of Electrostatic Precipitation. Chinese Society of Electrostatic Precipitation, 2005.
2. Indian Power Stations. Proceeding of the Conference. NTPC, 2008.
3. Misaka T. et, al. Recent Applications of Moving Electrode Type Electrostatic Precipitator. Proc. of 7th Int. Conf. on Electrostatic Precipitation. 1998, 508-515.
4. Misaka T. et, al. Improvement of Reliability for Moving Electrode Type Electrostatic Precipitator. Proc. of 10th Int. Conf. on Electrostatic Precipitation. 2006, paper 9A1.
5. Okkes A.G. Get Acid Dew Point of Flue Gas. Hydrocabon Processing. 1987, 53-55.