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IMPROVEMENT OF RELIABILITY FOR MOVING ELECTRODE TYPE ELECTROSTATIC PRECIPITATOR

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ABSTRACT
A moving electrode type electrostatic precipitator, which is equipped with brushes to remove dust from the moving collecting plate surface, is effective in collecting high resistivity dust. The collecting plate of the moving electrode type electrostatic precipitator is divided into strips, coupled with chains and moved by driving wheels. In Japan, 51 units of the moving electrode type electrostatic precipitator have been manufactured since 1979.

For the moving electrode type electrostatic precipitator, an important factor is to improve the reliability of the moving component parts such as the movable collecting plate element, the rotating brush, the chain and so on. These parts are refined and the life spans of these parts are evaluated by actual operation results.

There is an upper limit of inlet dust density for the moving electrode type electrostatic precipitator. Fixed electrode sections are commonly combined as a pre-collector to reduce dust density at a moving electrode section. A collection performance equation has been studied using the combination of fixed electrode sections and a moving electrode section.

INTRODUCTION

Electrical resistivity of dust greatly affects dust collection efficiency of an electrostatic precipitator (ESP). High resistivity dust problems are characterized by excess sparking and back corona. So, the collection efficiency of ESP for high resistivity dust is decreased severely. For this reason it is important to improve the collection efficiency of an electrostatic precipitator for high resistivity dust.

Hitachi Plant Technologies has developed a moving electrode type electrostatic precipitator that prevents back corona by removing the collected dust using rotating brushes and movable collecting plates[1-3]. The combination of a moving electrode section and conventional fixed electrode sections, named MEEP, is applied to the field of wide industry. Since 1979, Hitachi Plant Technologies has a supply record of 51 MEEP units in Japan.

This paper describes recent refinements of main component parts and reliability improvements of the moving electrode section and a performance calculation method on combination of fixed electrode sections and the moving electrode section.

STRUCTURE AND FEATURE OF MOVING ELECTRODE TYPE ESP

Fig. 1 shows the overall structure of the MEEP installed for the 1,000MW coal fired utility boiler in1993. Applicable MEEP to the above conditions is 8 parallel sections and 3 series sections. The first and second sections at the inlet side are fixed electrode sections and the outlet one is a moving electrode section.

Fig. 2 shows the sutructure of a moving electrode section and a fixed electrode section. Generally the conventional fixed electrode type ESP consists of discharge electrodes and collecting electrodes. Dust in gas is collected to the collecting plate and collected dust is dislodged from the collecting plate to a hopper by mechanical rapping of a hammer.

At the moving electrode section, the collecting plate is divided into strips, coupled with chains and moved by driving wheels slowly. The discharge electrodes are installed between collecting plates at the collection zone. Dust is collected to collecting plates by electrostatic force as the treatment gas flows through the collection zone. The collected dust attaches to the collecting plate and is then transferred to the non-collection zone without gas flow in the hopper until the dust layer becomes thick enough to cause back corona. In the non-collection zone, the rotating brushes are located and sweep away collected dust from movable collecting plates; therefore the collecting plates are kept clean at all times.

The moving electrode section has many advantages. First, as the collecting plates are kept clean by brushing, the moving electrode section can prevent back corona and can collect high resistivity dust effectively. Secondly, collected dust is removed by brushes at the hopper of ESP, therefor it is not necessary to consider the rapping re-entrainment from the collecting plate. The visibility of smoke at a stack becomes clear continuously.

In order to use the moving electrode section, there are a few considering points. First, the reliability establishment of moving component parts, such as movable collecting plates, rotating brushes and chains, is one of the most important factors to stable operation and easy maintenance. Secondly, for the moving electrode section, there is an upper limit of inlet dust density. The fix electrode section is commonly combined with the moving electrode section for a pre-collector.

RELIABILITY IMPROVEMENT OF MOVING COMPONENT PARTS

Reliability improvement of moving component parts of a moving electrode section is one of the most important factors to evaluate general reliability including stable operation and easy maintenance. Hitachi Plant Technologies has refined a movable collecting plate, a rotating brush, a chain, and other main components through 27 years of experience since the supply of the first unit. Operation results of actual units ensure the reliability of component parts.

Movable Collecting Plate

The shape of a movable collecting plate element is required flat and smooth to reduce build up of dust and brush off adherent dust easily. The movable collecting plate element consists of a flat plate and a reinforcement frame, and the elements are connected with chains by fittings. Fig. 3 shows a conventional collecting plate element and an advanced collecting plate element. As design limit on deflection of the element, a conventional movable collecting plate element was applied in the range of 2,500 to 2,900mm width.

Nowadays, a large width type element is required to reduce outlet dust density by extension of gas treatment time of the moving electrode section. A high reliable new type element was developed and is used in the range of 3,500 to 4,500mm width. The shape of the new type element is flat. The element is contacted to elemental wires of rotating brushes smoothly, then the lifetime of rotating brushes can be expanded. The new type element has been applied since 1997, and its reliability has been confirmed by actual operations.

Rotating Brush

The rotating brushes for dust removal are installed in the lower zone of the collecting plate. The lower zone is a non-collection zone, which is free from gas flow in the hopper. A rotating brush consists of a rotary shaft and channel brushes in which elemental wires are implanted in the channel brushes, and a rotary shaft where channel brushes are installed spirally. The structure of a rotating brush is shown in Fig. 4.

The diameter of rotating brushes decreases by bending and fatigue of elemental wires in channel brushes. The wiper distance of rotating brushes is designed to be easily adjustable. From actual operation results, it became clear that the wiper distance should be adjusted at the time of a periodic inspection, every one or two years. A measurement result of quantity of abrasion of a brush is shown in Fig. 5.

According to the combination of rotating brushes and the conventional movable collecting plates, the quantity of abrasion became almost 25 mm of an exchange limit in eight years. In the case of the combination of rotating brushes and the new movable collecting plate elements, abration of rotating brushes decreased almost one half compare to the combination of the conventional collecting plate. The exchange interval will be expected over 15 years according to 6 years actual operation results.

Chain

Chains are used to connect moving electrode elements and to move collecting plates by driving wheels. Conventionally, a link chain was selected for driving the moving electrode elements because of its simple shape and less trouble happened when catching dust. Nowadays, a roller chain is used considering the lifespan of the chain. The shapes of the link chain and the roller chain are shown in Fig. 6.

In case of the link chain, round bars contact at one point, where load of moving electrode is added, and a contact point is rubbed together. On the other hand, the brush and the roller of the roller chain contact each other linearly. Detail of contact point is shown in Fig. 7. It was thought that the lifespan of the roller chain would be longer than the link chain because of the difference in the contact point and the chain pitch. The pitch of the roller chain is 2.5 times longer than the link chain pitch.

Fig. 8 shows the relationship between operating time and extension of chain. The vertical axis shows the value that divided extension value of a chain with full length of a chain. According to actual operation results from 1981, the lifespan of the link chain was around 8 years. The extension of the roller chain was less than one fifth of the link chain. The lifespan would be estimated more than 15 years from the actual usage of 8 years.

PERFORMANCE CALCULATION ON COMBINATION OF FIXED ELECTRODE SECTION AND MOVING ELECTRODE SECTION

In order to use the moving electrode section, the fixed electrode sections are commonly combined for a pre-collector to limit the dust density at the moving electrode section. Collected dust at the inlet side section is rather coarse and its dust resistivity is relatively low. Therefore, dislodgement by mechanical rapping is easy at inlet side section.

Then the moving electrode type ESP is mainly used in combination with conventional fixed electrode sections upstream and a moving electrode section downstream. Utilizing characteristic of a moving electrode section, remodeling from a fixed electrode section to a moving electrode section is useful for the purpose of improving collection performance of an existing ESP. In addition, it is effective to add a moving electrode section in outlet side of an existing ESP as retrofit.

In the case of combination with a fixed electrode section and a moving electrode section, the equation of dust collection performance was studied using measurement results with a moving electrode type ESP.

Collection performance of an ESP is shown in Deutsch equation[4)]. In the consideration of particle size distribution of dust, S. Matts proposed modified Deutsch equation[5)] is shown in Eq. 1. Nowadays, this equation is mainly used for planning of an ESP sizing.

$$\frac{C_o}{C_i} = \exp\left\{-(\omega k \times f)^k\right\} \qquad (1)$$

In this modified equation, Matts introduced a coefficient **k** regarded as a function of particle size distribution. In case of fly ash from coal fired boilers, the coefficient **k** assumed about 0.5[5)]. The migration velocity w**k** and the coefficient **k** can be calculated in Eq. 2 and Eq. 3 with measured values of inlet and outlet dust density in different specific collection areas **f**.

$$\omega k = \frac{(-\log P2)^{\frac{1}{k}}}{f2} \qquad (2)$$

$$k = \frac{\log\left(\frac{\log P1}{\log P2}\right)}{\log\frac{f1}{f2}} \qquad (3)$$

Where, **P1** and **P2** is penetration of dust calculated from Eq. 4 with inlet dust density **Ci** and outlet dust density **Co** at **f1** and **f2**.

$$P = \frac{C_o}{C_i} \qquad (4)$$

In case of the combination of a fixed electrode section and a moving electrode section, it is thought that different migration velocities w**k** are given from fixed electrode section and moving electrode section each other. Relation of specific collection area and penetration of dust, when a fixed electrode section and a moving electrode section were combined, is shown in Fig. 9.

It was thought that the coefficient **k** in the moving electrode section was the same as it in the fixed electrode section. Because particle size distribution at the moving electrode section should be changed while passing though fixed electrode sections. The collection performance equation when a fixed electrode section and a moving electrode section were combined can be converted into Eq. 5 from Eq. 1.

$$\frac{C_o}{C_i} = \exp\left\{-(\omega k1 \times f2 + \omega k2 \times f3)^k\right\} \qquad (5)$$

Where, w**k2** and **fa** can be calculated with Eq. 6 and Eq. 7.

$$\omega k_2 = \frac{\left(\log \frac{1}{P3}\right)^{\frac{1}{k}} - \left(\log \frac{1}{P2}\right)^{\frac{1}{k}}}{f3} \qquad (6)$$

$$fa = f2\left(1 - \frac{\omega k1}{\omega k2}\right) \qquad (7)$$

Penetrations **P** were measured at a coal fired boiler in a power station where installed an existing fixed electrode type ESP and a new MEEP. The results of penetrations measured each section of fixed electrode sections and a moving electrode section are shown in Fig. 10.

The migration velocity w**k1** of dust and a coefficient **k** have been determined from penetration values of fixed electrode sections. The migration velocity w**k2** at moving electrode section was calculated from the penetration of the moving electrode section. The migration velocity w**k2** of moving electrode section was 1.7 times higher than it of the fixed electrode section.

It means that the collection performance of the moving electrode section is higher than that of the fixed electrode section. The coefficient **k** became almost 0.5.

From this result, the collection performance that combined a fixed electrode section and a moving electrode section can be calculated with Eq. 5 by combining migration velocities of a fixed electrode section and a moving electrode section. From this result, it became clear that the collection performance, as for different collection rooms of migration velocity was combined, could be calculated in Eq. 5. This calculation method can apply to combinations of different electrical charging sections as well as a combination of a fixed electrode section and a moving electrode section.

CONCLUSION

(1) Main component parts of a moving electrode type electrostatic precipitator were refined, and reliability was improved sufficiently.

(2) The shape of a new type moving electrode element does not have irregularities, and is smooth to contact with rotary brushes. Therefore the life span of rotating brushes expanded greatly.

(3) The chain of a moving electrode adopted a roller chain. The elongation of a roller chain reduced to one fifth in comparison with a link chain, and the lifespan expanded.

(4) The collection performance equation was studied in the condition that combined collecting sections of different migration velocity. The calculation method of collection performance that combined different migration velocity with modified Deutsch equation was calculated and made clear.

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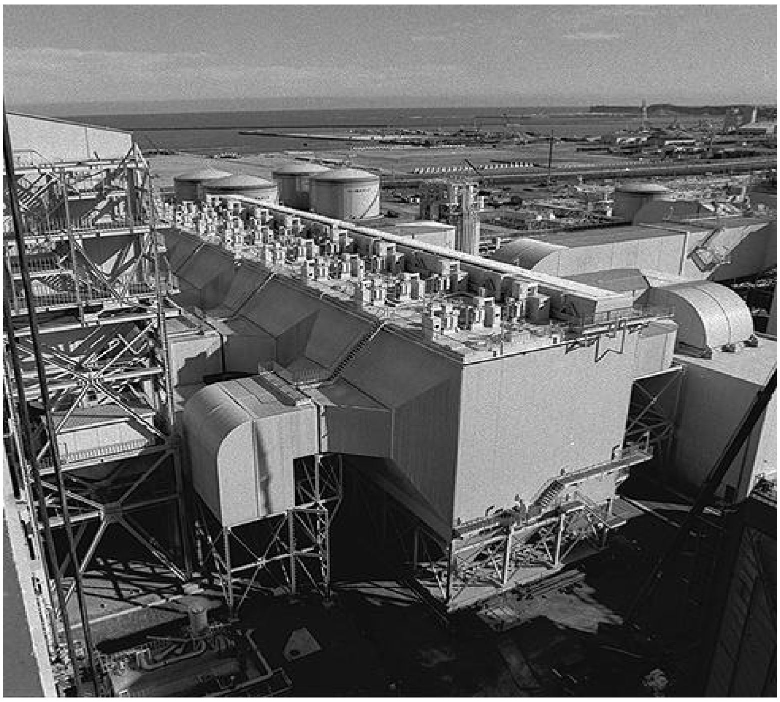

Fig. 1 Application of MEEP for 1000MW Coal Fired Utility Boiler

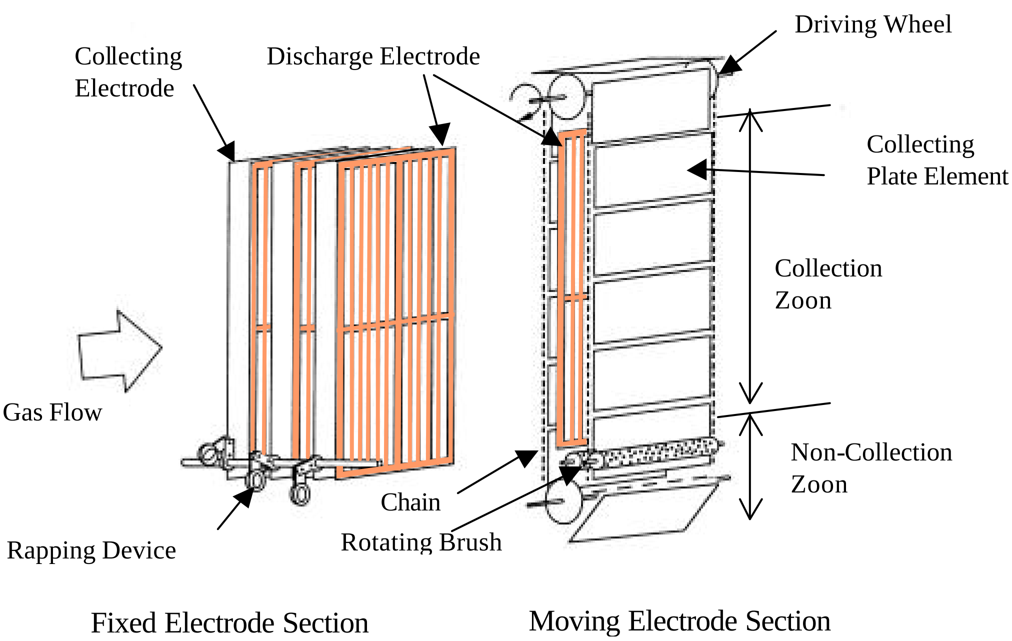

Fig. 2 Structure of Moving Electrode Section and Fixed Electrode Section

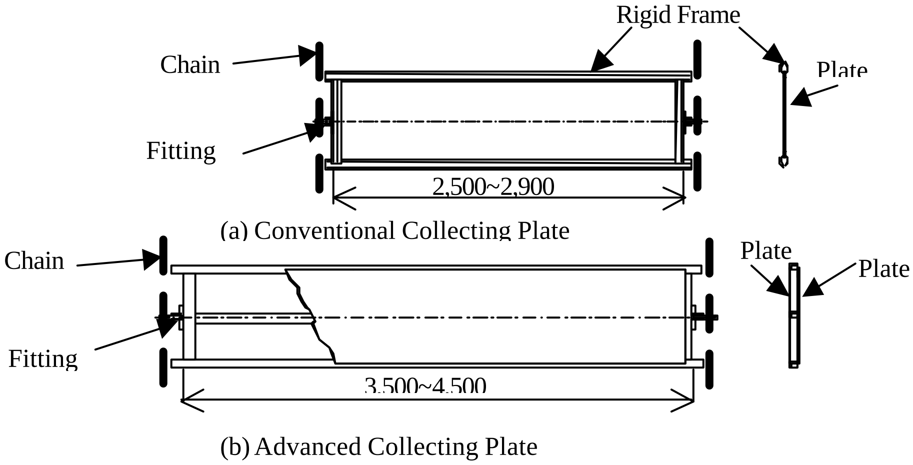

Fig. 3 Refinement of Collecting Plate Element

Fig. 4 Segmental Model of Rotating Brush

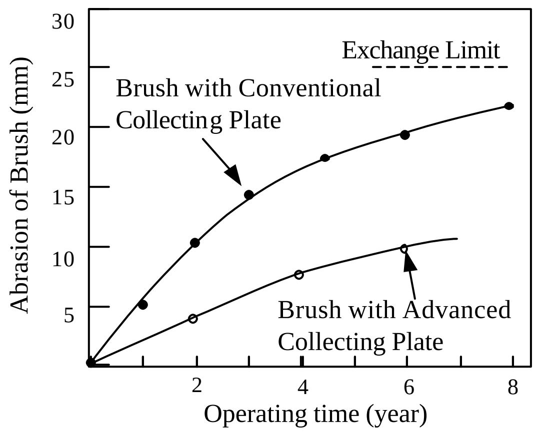

Fig. 5 Abrasion of Brush

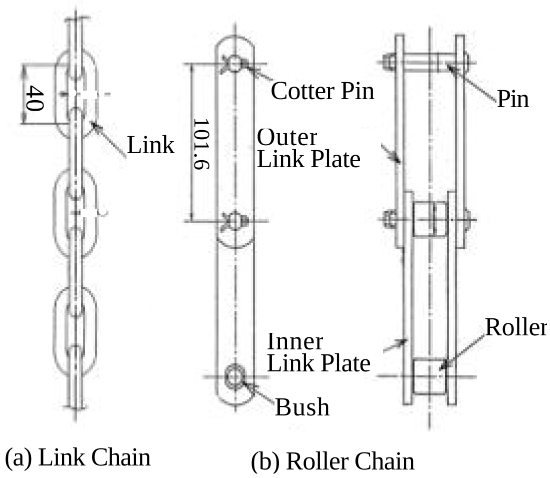

Fig. 6 Schematic of Chain

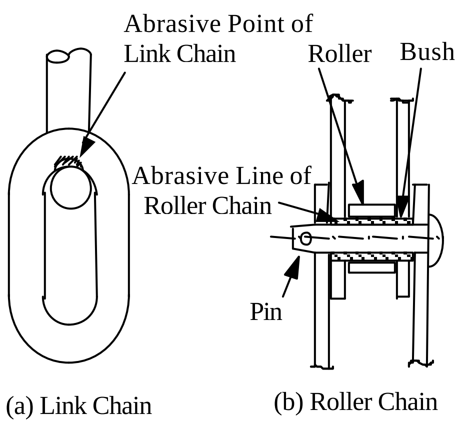

Fig. 7 Contact Point of Chain

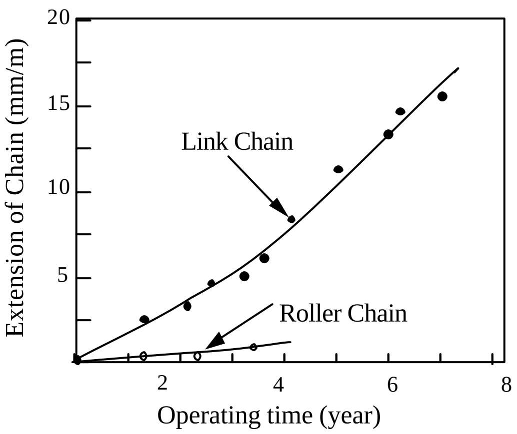

Fig. 8 Extension of Chain

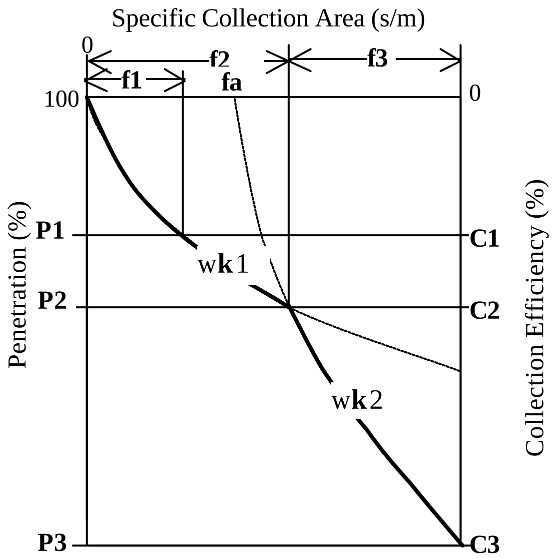

Fig. 9 Relation of Specific Collection Area and Penetration

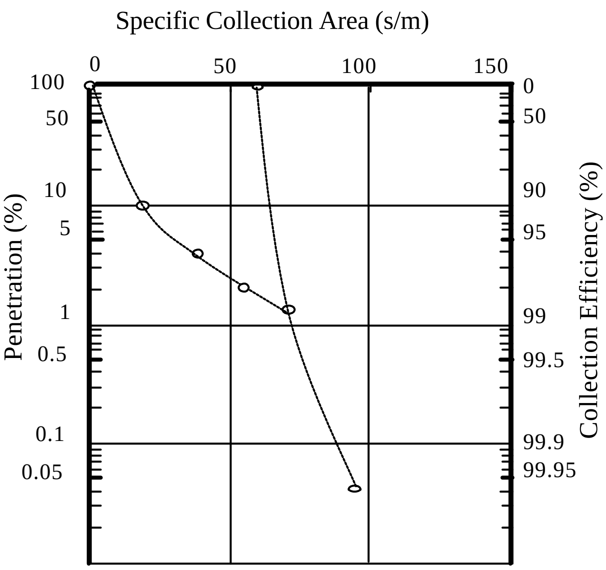

Fig. 10 Measurement Result of Penetration In a Power Station