

Study on brush of moving electrode type electrostatic precipitator (MEEP)

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Abstract. MEEP was an efficient particle removal technology for coal plant and sintering machine. As the stability of brush in MEEP was relatively poor, the experiments was designed for the brush which was made by 0Cr18Ni9 stainless steel wire to find the failure mode and cause. Combining the results of the experiments, the failure models of brushes were different under different conditions and the brushes were suitable for being used in the condition of small diameter particles. And the life span of brushes can be more than 6 years.

1. Introduction

Dust re-entrainment and back corona were the major limiting factors for particle collection of electrostatic precipitator (ESP), and could be overcome by moving electrode type electrostatic precipitator (MEEP). The installed capacity of MEEP was more than 50GW in coal-fired power plants before 2016. And the outlet particle concentration of MEEP could be reduced to less than 5mg/m³ in coal-fired power plant [1].

Meanwhile, MEEP had been evaluated as one possible Best Available Techniques(BAT) for sintering machine by European Commission in 2000[2].The number of MEEPs used in sintering machine feed end was more than 13. And the outlet particle concentration could be reduced to less than 10mg/m³ in sintering machine feed end before 2017[3-6].

The MEEP showed a high particle remove efficiency by the movable collecting plates and using rotating brushes to remove the collected particles as shown in Figure.1. At the same time, however, with the running time increasing, the stability of moving parts especially the brush as showed in Figure.2 usually would be a problem [7], which had slowed down the MEEP used in coal-fired power plant and sintering machine. Therefore, studying for critical components was necessary.

2. Experiment device and test method

SUS 304 was the brush wire material of the MEEPs used in Japan [8-9].The material of the brush wires which would be tested in the experiment was 0Cr18Ni9 stainless steel instead of SUS 304.

The experiment would be taken to find the major cause of failure and its mode, then put forward solutions according the experimental results and assessed the mean life span.

The brush experiment device as showed in Figure.3. It consisted of two fields and tested the brush under particles or not respectively. In the test field under particles, the particles were stored by the hopper and fed by the function of co- ordination with a vibrator and disengaging mechanism. The particles evenly drop to the brush wires and plate interface.



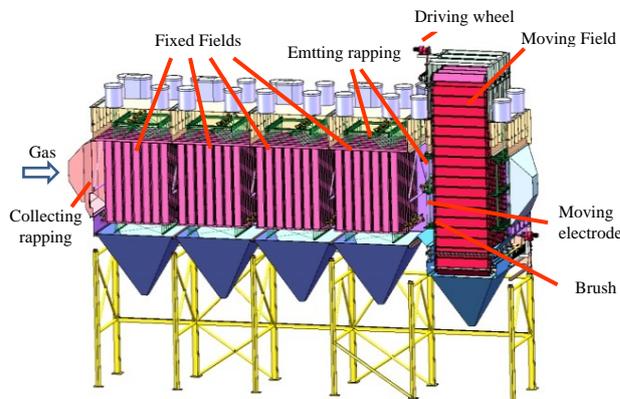


Figure 1. Sketch of MEEP

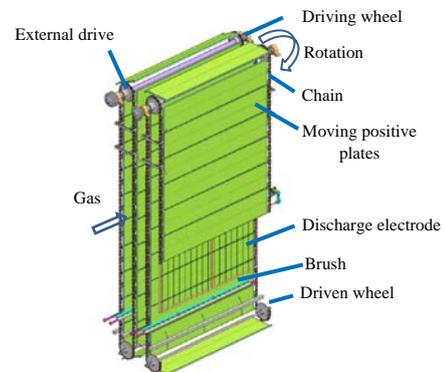


Figure 2. Components of moving field

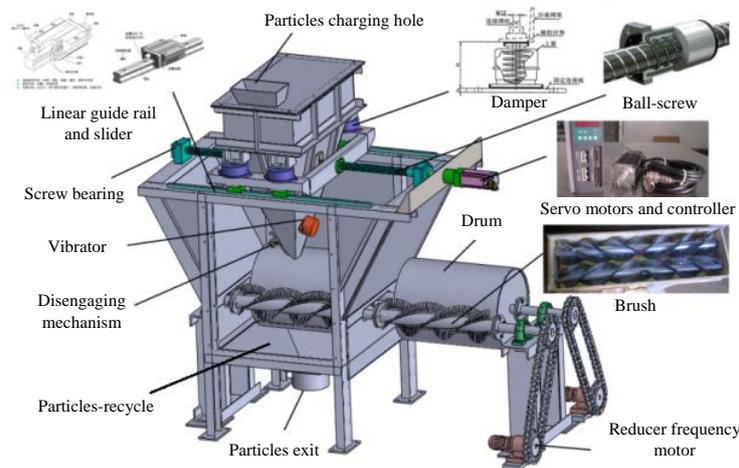


Figure 3. Brush experiment device.

It was easy to know, the gaps between moving positive plates would influence the fatigue of brush wires, and the linear movement of the plates would take a large space.

To solve the problems above, the experiment device took a drum with cracks to simulate the moving positive plates as showed in Figure.4. The drum rotating simulated the moving positive plates linear moving. And the interface between brush wires and plate was on a similar plate as the same.

Figure.5 shows the details of the drum. It consisted of two plates at the circumference. The drum completed one revolution, equalizing two plates completed linear movement.

The material of the moving positive plates was SPCC [10]. To make the other conditions equals, the drum surface had also used SPCC and had been taken by the same welding technology. What's more, the impact of distance and frequency by the gaps were equivalent between experiment device and MEEP.

In MEEP, the rotate speed of brushes was 7.8r/min and the moving speed of positive plate was 0.5~1.5m/min, while the relative linear velocity between brush and moving positive plate was 0.04m/s. As the relative linear velocity was a major influence factor to bush failure, the experiment device took two independent reducer frequency motors for brush rotating and positive plate moving.

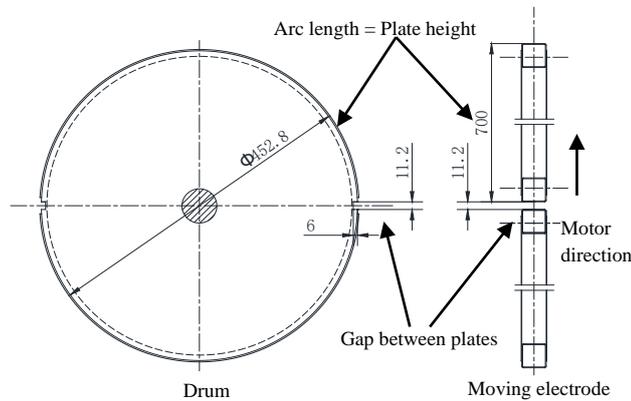


Figure 4. Drum simulating moving electrode .

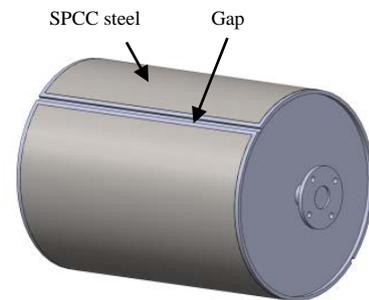


Figure 5. Sketch of the drum.

3. Testing results and analysis

3.1. Experimental preparation

(1) Material analysis

The material of the brush wires in brush was 0Cr18Ni9 stainless steel which was a type of austenitic grade stainless steel, and it was as suitable for applied in MEEP as its plastic and corrosion resistance. The surfaces of brush wires under microscopic vision field (400) as showed in Figure.6.

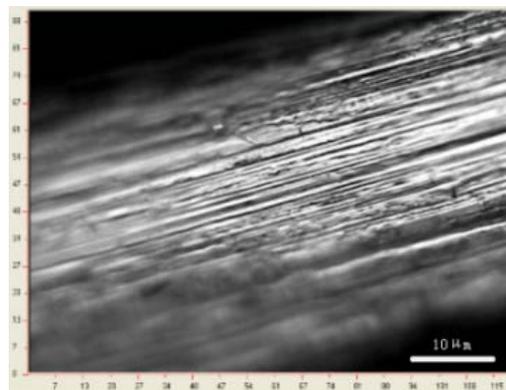


Figure 6. Sketch of the drum

(2) Pressure analysis

Figure.7 shows the interface between brush wires and plate, where the ash removed from dust collection plates by brush. The force from brush wires to plant is proportional to the deformation as its elastic deformation.

The contact area moving with the brush rotated and covered the all regions of the collection plates as shower in Figure.8.

As showed above, if with a low rotational speed of brush, some regions of the collection plates would miss the cleanout form brush and it would result in low dust removal efficiency. Therefore, enough rotational speed of brush is needed.

Figure.9 shows the pressure of brush in a deformation region. If with a low pressure from brush, the particles removal effect would be low. And if with a high pressure, the lifetime of brush might be short. Therefore, the pressure from brush to plate should be measured.

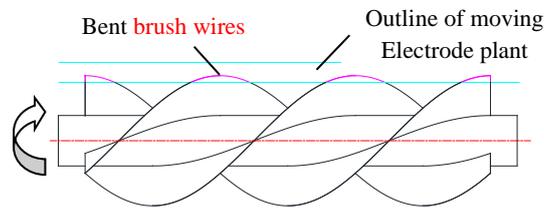


Figure 7. Pressure situation of brush.

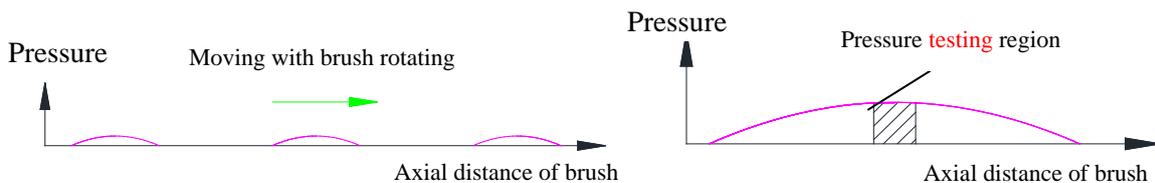


Figure 8. Pressure of brush.

Figure 9. Pressure of brush in a deformation region.

(3) Measurement points and tool

To reduce the measurement error, the measurement points designed as showed in Figure.10. The points were marked with A to G, and measured the same point at different test time.

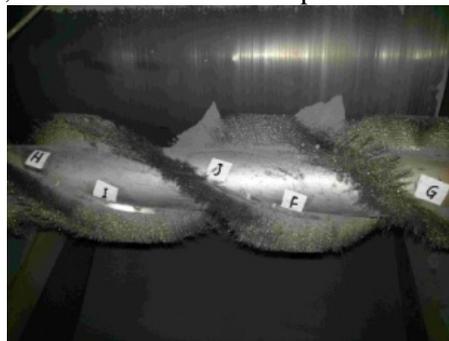


Figure 10. Measuring points of brush.

As the helical-structure of brush, conventional tool could not measure the failure length. Figure.11 shows the design of measurement tool and Figure.12 shows the actual use. Put the tool in the strip at a measurement point, and took the arc as fixed position. Then, it was easy to read the failure length from the scale in the tool.

3.2. First test

The diameter of the wires on the brush was 0.15mm and the relative linear velocity between brush and plate was 0.388m/s. One day equal ten days in the accelerated test. The particles added in the test field under particles of the experiment device came from a plant and the median diameter of the particles was 45µm as shown in Figure.13. The test field without particle was tested along.

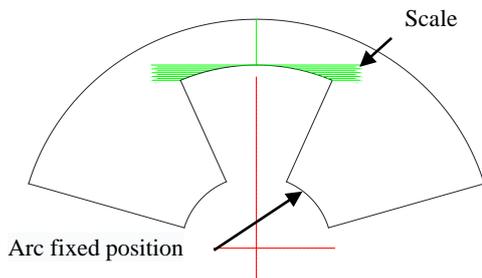


Figure 11. Design of brush measuring tool.

Figure 12. Abrasion measure of brush.

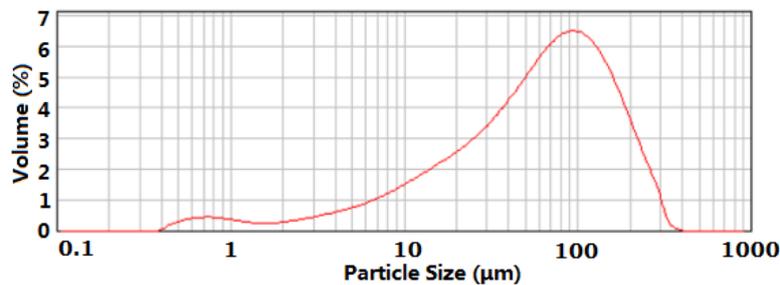


Figure 13. Particle size in first test.

The Amount of compression was 1m, the failure length in the test field under particles was 10mm after 30days of testing which was equal 300days in practical. As shown in Figure.14, in the test field under particles, the head face of the brush wires in the middle of the strip was slant plane. The wires were seriously worn near the plates and seriously permanent bend beside the plates. On the other hand, in the test field without particle, the brush wires only presented the failure length of 1.6mm.



Figure 14. Head face of the brush wires in the test field under particles.

The particles with the median diameter of 45µm feed in the interface between brush wires and plate exacerbate the failure by contrast experimentation.

3.3. Second test

The first test above showed that the median diameter of particles was a major influence factor to brush wires failure. As the particles used in the first test were mixture dust and came from the ash storage in plant. However, the brush of MEEP used in plant was usually set in the last field and the particles were very small.

Due to the reasons above, the second test was took with the particles came from the last field of ESP and the median diameter of the particles was 5.5µm as shown in Figure.15. Other experimental conditions were same as the first test.

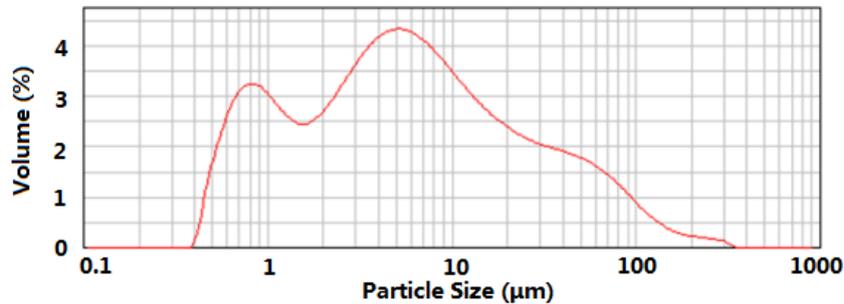


Figure 15. Particle size in second test.

The experimental results as showed in Figure.16. The failure length which consisted of permanent bend and abrasion in the test field under small diameter particles was 1.8mm after 30days of testing which was equal 300days. It was anticipated that the failure length would be after 2.28 years tested. The max failure length was 5mm as shown in Figure.17 and the max distance between brush and plate was 15mm. The distance between brush and plate should be adjusted when the failure length reached 5mm every 2 years and could be adjusted 3 times. The lifetime of brush could be more than 6 years according the experimental results and meet the requirement of a major repair cycle of MEEP.

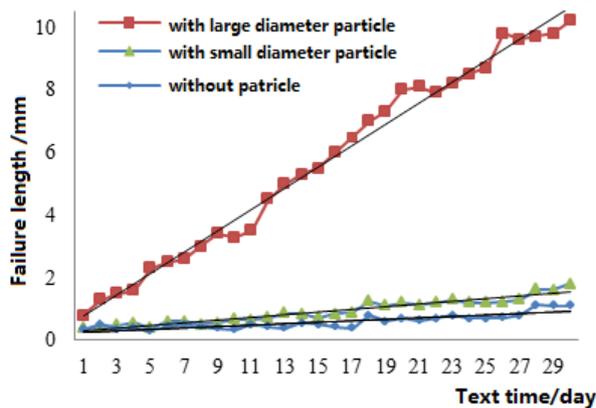


Figure 16. Failure length of brush changes.

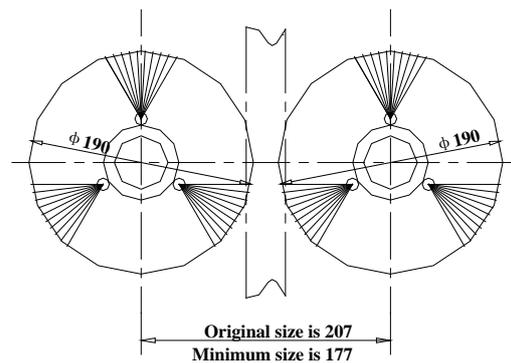


Figure 17. Adjust distance between brush and plate.

4. Field applications

The field applications were studied to analysis the results combined with the lab tests. Then it evaluated the lifetime of brushes.

The MEEPs in Feng cheng plant in China's Jiang xi province and Da la te plant in China's Nei meng gu province had run 1 year and 6 years, respectively. As shown in Figure.18 and Figure.19.



Figure 18. Brush of MEEP in Feng cheng plant.



Figure 19. Brush of MEEP in Da la te plant.

The abrasion of brushes was not obvious. The major phenomenon was permanent bent to two sides. The brushes of MEEP in Feng cheng plant removed particles well as the contact surface became larger, although the pressure from brush to plate decreased.

The failure length phenomenon was appears on locally as the brushes had used for 6 years without being adjusted. The distance between brushes and plates should be adjusted.

The failure mode was permanent bend to two side of the stripe according the lab tests and field applications. During 2 years, the brushes can remove particles from moving positive plates well as the contact surface became larger, and the distance between brushes and plates should be adjusted ever 2 years.

5. Conclusions

Through the comparison tests of bench-scale experiment, as big particles accelerated brush wires wear, the brush was suitable for being used in the condition of small diameter particles at the end electric fields instead of the front electric fields.

Through the track tests of MEEPs operated in actual coal-fired power plants, the major phenomenon of brushes was permanent bent and the abrasion was not obvious.

Brush life span would be more than 6 years and the distance between brush and plate should be adjusted ever 2 years when it was made of 0Cr18Ni9 steel.

Acknowledgement

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