Corona discharge with bundle of very fine conductive fibers

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***Abstract*— In order to improve durability against dust contamination and to lower operating voltage of electrostatic precipitation, characteristics of corona discharge generated with a bundle of fine metal fibers with diameter of 12 μm have been studied. Compared with the conventional corona electrode made of 0.8 mm diameter wire cut vertically, the corona starting voltage decreased and the corona current becomes larger. Tip of the bundle stretched out, and several outside points glow to emit corona current.**

1. Introduction

For corona electrodes of industrial electrostatic precipitators, wire, sawtooth or needle made of metal are commonly used[1-3]. In order to improve safety against high voltage or ignition due to flashover, further decrease in operating voltage has been required. For practical application, maintenance is necessary for ESPs[4] due to dust contamination, especially on the tips of corona electrode[5].

Sharpening the electrode tip could improve the V-I characteristics[6]. This could also improve the problem of dust contamination since the area of the tip decreases with decreasing radius at the tip, therefore dust deposit could be eliminated. Recently we noticed that bundle of fine metal fibers may improve the corona characteristics while assembly of the electrode system would not be difficult. The bundle of metal fibers composed of several 12μm has been used as a brush for static charge eliminator of copy machines, and this could be used as the corona electrode. There were reports on carbon fibers for corona electrode[7, 8]. This material, however, is weak against flashover, and practical application has been difficult. Metal fiber is more stable, and can be used for longtime operation. In our knowledge, there has been no reports on the corona discharge using a bundle of this metal fibers, therefore, we studied the characteristics of corona discharge generated using a bundle of metal fibers.

2. Experimental Apparatus

The electrode is shown in Figure 1. The bundle of metal fibers for the corona discharge consists of 100 fibers with 12 μm diameter made of stainless steel. Overall diameter of the bundle is approximately 800 μm. 21 bundles are set in parallel with the electrode separaaration, ds = 15 mm from the tip to the plate, and interval, di = 5 mm.

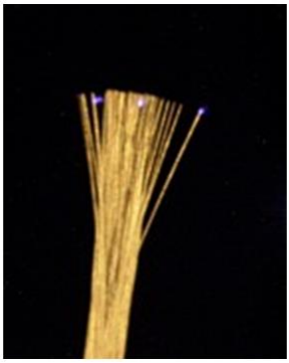


Figure 1 Bundle of fine metal fibers
(100 fibers of 12 μm diameter made of stainless steel)

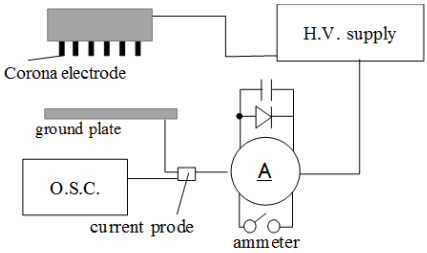


Figure 2 Measuring circuit

For comparison, V-I characteristics of the needle electrode made of 0.8 mm wire, used in our products were measured. The measuring circuit is shown in Figure 2. In addition, using a long-working distance-microscope, the tip was observed.

3. Experimental Result

Figure 3 shows the V-I characteristic of the corona discharge with ds = 15 mm. The results indicate that the corona starting voltage is around -3 kV, and at -10kV the current was 170μA. With the conventional needle, the corona onset was -7 kV, and the current was 60μA at -10 kV.

Figure 4 shows the microscopic photograph of the tip of the bundle with negative corona. With the higher voltages, the fibers locating outside of the bundle are gradually spreading out. Due to electrostatic force, the spreading takes place. Repulsive force takes place between the fibers with the same polarity. Attractive force towards the ground electrode also affects the movement of the tips.

With increasing voltages, a few tips of the spread-out fibers start glowing, generating corona discharge. From the photographs, this glow is difficult to recognize, but with careful observation during the experiments, we confirmed this fact.

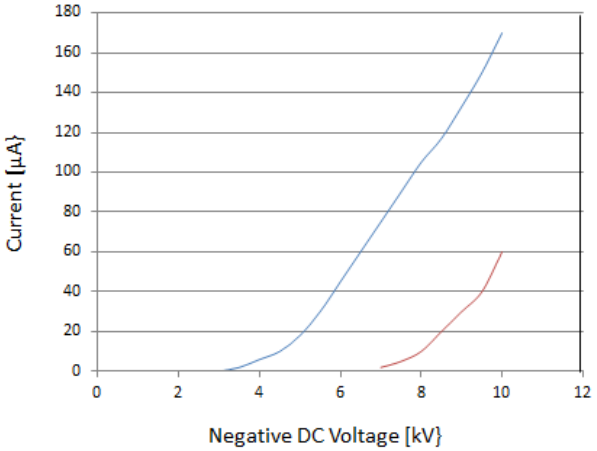
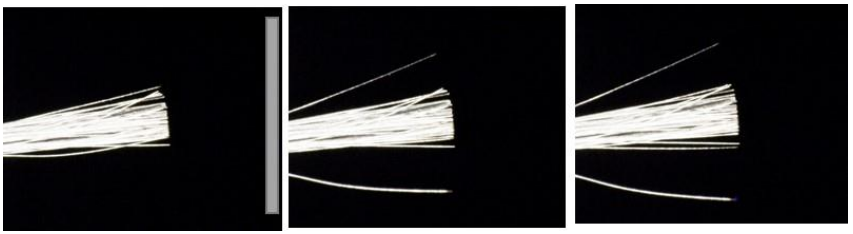


Figure 3 Voltage-current characteristics of the bundle and the needle electrode



0.0 KV - 3.0 kV - 6.0 kV

Figure 4 Movement of the tip of the bundle of the metal fibers

4. Conclusion

From the experimental study of the corona discharge with the bundle of 100 stainless steel fibers with 12 μm diameter, following conclusions are obtained.

(1) Onset voltage of the corona discharge can be lowered significantly with the bundle of metal fiber compared to conventional needle electrode.

(2) Compare with the conventional needle electrode of 0.8 mm diameter, larger corona current can be obtained with the bundle.

(3) The tip of the bundle spread out when high voltage is applied, and some of the tips, not all, locating outside of the bundle glow and generate corona discharge.

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