Characteristics of a Dry Fog Ionizer

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Abstract. The newly developed "Dry Fog Ionizer" generates charged dry fog. The dry fog consists of very fine water droplets 8μm in mean diameter. This system consists of a dry fog nozzle (H.Ikeuchi & Co., LTD.), a ring electrode for induction charging (50mm outside diameter, and 10mm thick) in front of the nozzle, and a fan for dissipating charged dry fog. The ring electrode is DC or AC-biased and fine droplets ejected from the nozzle are electrified by induction charging. The particle size of the charged water droplets are reduced through evaporation during the transporting process by air flow, and completely evaporate approximately 2m from the nozzle under normal atmospheric conditions (25 °C, 60% R.H.) leaving high density ions. Using this system, high density ionic space charge can be realized in a remote spot from the ionizer. By this principle, the Dry Fog Ionizer shows strong charge-eliminating ability in the region away from the ionizer. When a dc bias of 5kV was applied to a ring electrode with the rate of water flow from the nozzle being 2l/h, an ionic space-charge density of 1200nC/m³ was able to be obtained at a distance 2m away from the ionizer, which was 10² times the value produced by an ordinary corona-type ionizer with an air blower.

1. Introduction
In various industries ionizers which generates ions in the air are widely used for eliminating electrostatic charge. There are some types of ionizers with different ion generation mechanisms. Corona discharge is the most widely used method for ion generation. Corona-discharge type ionizers generate high density ions and have sufficient ability to eliminate charge. The effectiveness of eliminating electrostatic charge is dependent on the distance from the ionizer to the charged substance to be neutralized, and it decreases rapidly as the distance becomes larger. For this reason, in most cases, corona type ionizers are positioned very close to the charged substances.

Most corona-type ionizers use needle electrodes for generating corona discharge. Most of ions generated at the tip of the needle-type corona electrode are absorbed to the ground electrode and a part of the remaining ions are attracted to nearby charged objects as a result of the electric field between the electrode tip and the objects' charge. During the transfer process to the charged object, ions spread quickly throughout the surrounding space by means of self field formed in ionic space charge. For this reason, in the case that the charged object is not in the vicinity of the ionizer electrode, charge decay rate of the object becomes very slow.

In order to prevent this problem, an air-blow type ionizer was used. This type is composed of corona electrodes and an air blower. Though air flow aids to increase ion density at a distance from the
ionizer, its effect is not sufficient. The newly developed Dry Fog Ionizer can send high density ions to charged objects distant from the ionizer. In the present paper, the principle and the characteristics of the ionizer are described.

2. Experimental set up

2.1. Dry Fog Ionizer

The Dry Fog Ionizer generates charged dry fog. The dry fog consists of very fine water droplets 8μm in mean diameter. When dry fog collides with the surface of solid substances, it does not make the surface wet because the fine water droplets of dry fog do not burst when they hit the solid surface. The Dry Fog Ionizer consists of a dry fog nozzle (H.Ikeuchi & Co., LTD.), a ring electrode (outside and inside diameters are 50mm and 30mm, respectively) situated in front of the nozzle for induction charging, a fan for dissipating the charged dry fog distant from the nozzle, and a cylindrical insulator shield as shown in Fig.1. The ring electrode is DC or AC-biased and droplets ejected from the nozzle are electrified by induction charging.

The particle size of the charged droplets are reduced through evaporation during the transporting process by air flow, and the droplets evaporated completely approximately 2m from the nozzle under normal atmospheric conditions (25 °C, 60%R.H.). As the charge of each droplet is kept constant during the evaporation process [1], ions are left by-products of the evaporated water droplets. These ions are considered to be charged clusters of water molecules. As the mobility of charged droplets is much smaller than that of ions, they can be sent to the place away from the ionizer by air flow without a serious loss. Consequently, using this system, high density ionic space charge can be obtained at distances remote from the ionizer, which results in highly efficient charge neutralization.

Water droplets ejected from the nozzle are electrified in reverse polarity to that of the potential applied to the ring electrode. Usually, a few kV of DC or AC potential is applied to the ring electrode. When AC potential is applied to the ring electrode, positively and negatively charged fine droplets are generated alternatively. This system corresponds to the AC corona ionizer widely used in industrial applications.

The velocity of air flow from the fan is 4.4m/s at the position of the ring electrode, and the ejection rate of water from the nozzle is 2l/h.

2.2. Measuring system

The measuring system used in the present study is shown in Fig.2. It is composed of a Dry Fog Ionizer, both DC and AC high voltage sources with a high voltage meter and a current meter, a cylindrical Faraday cage with a suction pump and an electrometer. The cylindrical Faraday cage is used for measuring ionic space charge density in any area apart from the ionizer. The internal space of the cage is filled with metal cotton made of fine metal wire in order to capture ions absorbed from the inlet of the cylinder using a suction pump.
Ions generated from the Dry Fog Ionizer are measured as ionic charge using the cylindrical Faraday cage and the value is converted into space charge density using the air flow rate of the suction pump. In the present study, another measuring system is also used for measuring the charge-eliminating ability of the Dry Fog Ionizer as shown in Fig.3. In this case, a metal disc of 120mm in diameter which is electrically insulated from the ground was provided in place of the cylindrical Faraday cage. The metal disc was charged up to a predetermined potential and the decay characteristics were measured using a surface potential meter and a data acquisition unit. The capacitance $C$ of the metal disc was adjusted to be 120 pF.

![Fig.3 Experimental set up](image)

**3. Results and discussion**

**3.1. Characteristics of induction charging**

The fine droplets ejected from the nozzle are charged when they leave the tip of the nozzle in the electric field caused by potential difference between the grounded nozzle and the ring electrode. The droplet charge is considered to increase as the potential applied to the ring electrode becomes higher. The relation between the potential of the ring electrode and the ionic space charge is shown in Fig. 4. In this case, the cylindrical Faraday cage is set at a position 2m away from the ionizer outlet. As we observed from the data, the application of higher potential to the ring electrode does not always generate good results. First, the ionic space charge density rapidly increases with the increase of ring potential after which it shows saturation characteristics. At a high value of potential, it is considered that corona discharge may be generated at the surface of the ring electrode. Fine dust particles on the ring surface may concern the discharge. Corona discharge electrifies water droplets at the same polarity as that of the ring electrode. The charging polarity by corona discharge is opposite to that of

![Fig.4 Relation between ling potential and ionic space charge density](image)

![Fig.5 Ionic space charge as a function of distance from Dry Fog Ionizer(DFI)](image)
induction charging. From the results obtained, the ring potential is decided under 5kV in the present experiment.

3.2. Ionic space charge density
The Dry Fog Ionizer can disperse high density ions to the positions distant from the ionizer. In Fig.5, ionic space charge density is shown as a function of distance from the ionizer when DC potential is applied to the ring electrode. The density of ionic space charge generated by the Dry Fog Ionizer is almost 1800nC/m³ at an area 2m point from the ionizer. It gradually decreases the farther the distance from the ionizer, and at around 5m from the ionizer it becomes almost immeasurable.

In the same figure, the case involving the ordinal corona eliminator is also shown. The data of this case is obtained using the present ionizer in which water was not ejected from the nozzle and in which six needle electrodes for corona discharge was provided in front of the nozzle. In the case of the corona ionizer, we observe 10^5 less ionic space charge density in comparison with the present case.

3.3. Charge decay characteristics of charged body
Fig.6 shows charge decay characteristics of a metal disc as a function of time duration obtained using the present ionizer with the application of both DC(Fig.6a) and AC(Fig.6b) potential application to the metal disc. The distance $L$ from the metal disc to the ionizer is 2m. Initial surface potential $V_{so}$ of metal disc is 1kV.

In the case of DC potential application, the disc potential $V_s$ linearly decays against time duration, and after 5s the charge on the plate was completely eliminated. However, if the charged object is still exposed to the ionized space after its charge was completely eliminated ($V_s = 0 \,[\text{V}]$), it is electrified to reverse polarity.

When AC potential is applied to the ring electrode, the potential of the charged object, after sufficient exposure to the ionic space, is almost zero because of the existence of positive and negative ions. In the case of AC application, the charge decay rate is slower than that of DC application.

4. Conclusions
(1) A new ionizer using charged dry fog for eliminating electrostatic charge at considerable distances from the ionizer has been developed.
(2) The ionic space charge at a 2m distance from the ionizer was 1800nC/m³. At that spot a metal plate with a capacitance of 120pF was charged up to 1kV and the charge was completely eliminated after 5s exposure to the ionic space.

References
[1] A.K.Azad and J.Latham 1967 J. Atmospheric and Terrestrial Phys. 29 1403