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Ionization with Maxwell 2D

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Abstract – In this paper, Ansoft MAXWELL 2D Software is used to present a novel computation method to calculate the voltage required for the precipitation. Model geometry is proposed and simulated with balloon boundary condition, so as to get optimum directional voltage and electric potential. The Poisson and charge conservation equations are solved to evaluate the electric field and charge density distributions in the negative ion generator.

Keywords – Corona, Corona discharge, Negative Ions, ionization, electric field intensity, Negative Ionizer.

I. Introduction

Cosmic rays or point discharge in regions of enhanced electric fields form molecular ions. They are transported within the global electric circuit. Charging of atmospheric aerosols and the formation, in suitable conditions, of ultrafine aerosols is leaded by the presence of molecular ions. Electrification of aerosol modifies the aerosol coagulation rates and the rate of aerosol collection by cloud water droplets. Electrical changes to aerosol coagulation and collection have been suggested to influence water and ice clouds, respectively.

Ions produced by direct current generators by corona effect will add to and enhance the catalyzing effects that cosmic ray ions are now known to produce in, among other things, lowering nucleation barriers, stimulating charged particle growth and stability and increasing the scavenging rate in clouds.

The injection of a large number of DC corona effect ions will induce changes in cloud microphysics and cloud cover and, consequently modifications in weather conditions.

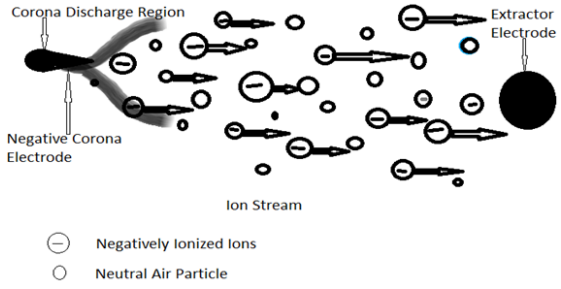

Fig.1. Ion stream of a DC electrostatic ionizer, where a high voltage is applied between the corona and extractor electrode

Description:

The mechanism of corona-induced ionic wind propulsion is illustrated in Fig. 1.[1] Gas molecules near the corona discharge region become ionized when a high intensity electric field is applied between a high tip curvature corona electrode and a low tip curvature collector electrode. The ionized gas molecules travel towards the collector electrode, colliding with neutral air molecules. During these collisions, momentum is imparted from the ionized gas to the neutral air molecules, resulting in the movement of gas towards the collector electrode.

II. Generation of Negative Ions

In the negative corona, energetic electrons are present beyond the ionization boundary and the number of electrons is an order of magnitude greater than in the positive corona. As gas temperature increases, the number of electrons increases. The electron energy distribution is independent of discharge polarity.

Individual electron avalanches that trigger successive avalanches at nearby locations forms negative corona. The total current from electrode is steady but it is composed of many pulses.-is a self sustained discharge and occurs when the electrical field at the surface of the conductor reaches a critical value [2].

III. Ansoft MAXWELL 2D

As described above for the ionizer model, for simulation Ansoft MAXWELL 2D electrostatic field solver is chosen as Maxwell uses the accurate finite element method to solve static, frequency-domain and time-varying electromagnetic and electric fields. [3].

Existing geometries used to generate negative ions are simulated and the results are used to propose the geometry which will be useful to generate more ions and give direction to the flow of ions.

The simulation space is broken down into following regions as follows:

- The surrounding air environment,
- Two walls of cylinder/cone to form an air channel,
- And finally, a conductive corona electrode at the other end of the air channel.

Below are the description and simulation results of the existing geometries.

Model with a cylinder and a needle penetrated in the center with a voltage of -20KV applied to the needle and ground to the cylinder is shown in the figure 2. The needle's length is 60mm and the diameter is 10mm. The Cylinders length is 70mm and the diameter is 50mm.

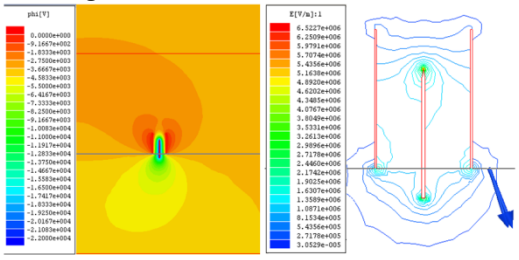

Fig.2. Maxwell output of the model with cylinder and needle

Model with a cone and a needle penetrated in the center with a voltage of -20KV applied to the needle and ground

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to the cone is shown in figure 3. The needle's length is 60mm and the diameter is 10mm. The cones height is 70mm, the upper diameter is 120mm and the base diameter is 50mm.

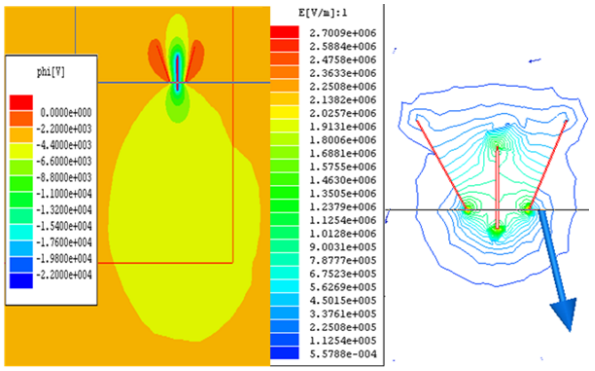

Fig.3. Maxwell output of the model with cone and needle

3.1 *Observation from the Simulation Results:*

When a high intensity electric field is applied to the corona electrode, gas molecules near the corona discharge region become ionized. Voltages and energy distribution with variable values at different points can be noted.

-2.7x10^3 V, 2.71x10^5V/m Cylinder with needle

-4.4x10^3 V, 2.25 x10^5V/m Cone with needle

The energy distribution from the simulation results is seen to be increased as we change the geometry from cylinder with needle and cone with needle.

IV. PROPOSED SYSTEM

We started with two point geometry, using two electrodes namely the ion generator electrode and the ground electrode representing them as cross sections with the dimensions mentioned as shown below in fig 4.

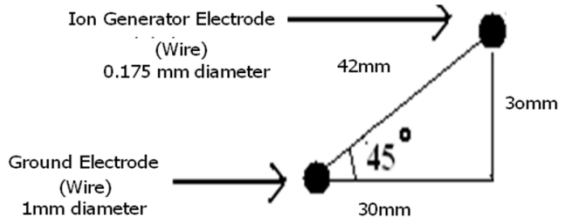

Fig.4. Model of ionizer without extractor used for simulation

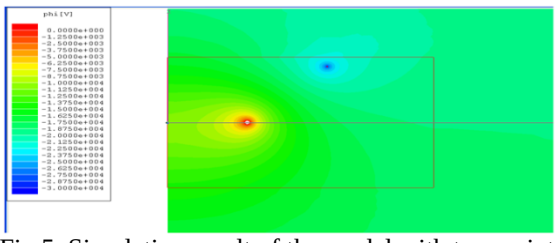

Fig.5. Simulation result of the model with two point geometry electrode arrangement

Observation:

- The simulation result showed that the ion generator electrode generated the ions (through the voltage distribution) but was not able to emit in the proper direction. The voltage is increased but now to give the direction to the flow of ions and in order to cause ions to create fluid flow, there must be an third accelerating electrode known as extractor
- Such an accelerating electrode is an attracting electrode placed upstream from the emitter electrodes in order to cause the ions to move in the intended direction.
- An extracting electrode consisting of an electrical conductor enabling continuous drain flow of electrons and ions from ionizing electrode and causing persistent ion flow into the atmosphere
- This design feature leads to the distribution of electric fields and design of electrode shapes most suitable for producing the air flow in the desired direction.

To give direction to the flow of ions, the model of Ionizer in which an ion generator which comprises of three electrodes is proposed:

– An ionizing electrode
– A ground electrode
– An extracting electrode consisting of an electrical conductor enabling continuous drain flow of electrons and ions from ionizing electrode and causing persistent ion flow into the atmosphere

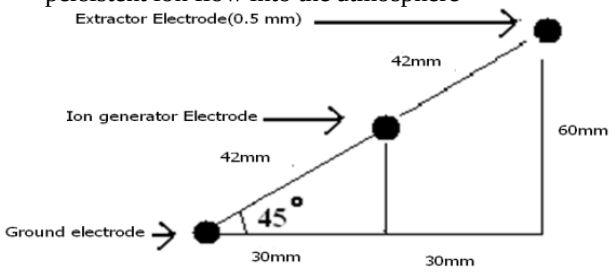

Fig.6. Model of ionizer used for simulation with extractor Electrode

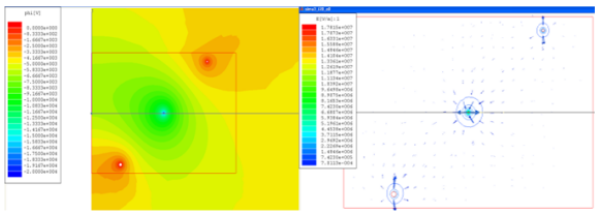

Fig.7. Simulation result of the model with extractor electrode

Observation:

The gap between corona and collecting electrodes can be divided into two regions, the ionization and drift zones. The ionization zone exists in close proximity to the corona electrode, in which air ionization occurs, and both positive and negative ions exist. The drift region, located outside the ionization zone, contains ions of a single polarity that have been driven out of the ionization region by the electric field. When the radius of the corona electrode is much smaller than the distance between corona and collecting electrodes, the ionization zone forms a uniform sheath over the coronating region of the corona electrode surface.

Table 1. Observation table of the simulations results for different voltages applied to the generator and extractor electrodes of the ionizer model

Sr. No.	GENERATOR ELECTRODE -KV	EXTRACTOR ELECTRODE -KV	GENERATOR V V/m		EXTRACTOR V V/m	
1.	20	Abs	-1.5x10^4	3.68x10^5	0	0
2.	30	Abs	-2.12x10^4	5.53x10^5	0	0
3.	***30***	***0***	***-5.88x10^3***	***7.42x10^5***	***-3.33x10^3***	***2.22x10^6***
4.	20	10	-1.33x10^4	9.05x10^5	-9.16x10^3	1.83x10^6
5.	20	15	-1.41x10^4	9.34x10^5	-1.66x10^4	3.11x10^5
6.	20	18	-1.75x10^4	2.7x10^6	-1.58x10^4	8.11x10^5
7.	***30***	***15***	***-2x10^4***	***6.78x10^5***	***-1.37x10^4***	***2.71x10^6***
8.	30	20	-2.12x10^4	5.63x10^5	-1.75x10^4	1.12x10^5

V. CONCLUSION

- To achieve a better directional property, extractor electrode higher voltage is added. The improved performance is expected to be achieved through a combination of electrode geometry, placement of the stages with respect to each other, and voltage pattern applied to the electrodes.
- Innovative solutions are employed by the designs used for the experiments in order to increase airflow by closely spacing electrodes while minimizing or avoiding the introduction of undesired effects.
- The ion generator electrode and extractor electrode are positioned parallel to each other extending between respective planes perpendicular to an airflow direction.

Future Scope:

- After getting desired results by changing the voltages, simulation will be carried out by changing the angle of the model and the distances between electrodes by keeping voltages constant, after getting suitable results by changing the voltages.

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