2012 International Conference on Lightning Protection (ICLP), Vienna, Austria

Influence of Thunderstorm-like Wind Velocities on Point Discharge Corona Currents

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***Abstract*—To study the influence of the wind speed on the generation of corona current in two different needles, a wind tunnel was designed and constructed. Needles were tested in a point-to-plane arrangement under laminar air flow. A constant background voltage is applied to the electrode arrangement, while air velocity varied from 0 m/s up to 16 m/s, a wind velocity near to thunderstorm conditions. Results show that the corona onset voltage of the needles is independent of the air velocity; however, the corona current magnitude increases with an increase of the air velocity.**

Keywords-point discharge corona currents; corona onset; wind tunnel;

I. INTRODUCTION

The Electromagnetic Compatibility Research Group EMC-UNC of the Universidad Nacional de Colombia is studying point discharge corona currents generated under natural atmospheric electric conditions. Recently, the wind effect on point discharge currents is investigated when different types of electrodes are used [1-2]. Similar studies are reported by other researchers [3-4].

A wind tunnel is designed and constructed to understand the behavior of the corona current at different wind velocities in order to compare the corona current values obtained under thunderstorm conditions. The wind tunnel is placed inside of a shielded room to avoid any kind of electromagnetic noise that may affect the measurements. See Figure 1.

The objective of the present research work is to understand the relationship between the corona current DC component and the air flow velocity. Additionally, the dependence of the corona onset voltage with the wind speed and the effect of the needle shape on the corona current magnitude are experimentally obtained.

II. EXPERIMENTAL SETUP

In order to guaranty a homogeneous background electric field, a plate to plate configuration with Rogowski electrodes is constructed and used, see Figure 2. In the center of this configuration a needle is placed to generate the corona current which is measured in the circuit shown in Figure 3.

Figure 1. Constructed Wind Tunnel. Notice that the electrodes are placed in the center of the wind tunnel. The white cylinder is the ventilator.

The electrode arrangement is placed inside of the wind tunnel chamber designed to allow laminar air flow.

During the experiment performed in Bogotá, Colombia (2600m o.s.l), the wind speed was variable, while temperature, pressure and humidity inside the chamber were stable. All variables were registered.

The main features of the experimental setup are the following:

A. Wind Tunnel

A wind tunnel is designed and constructed to perform corona current measurements with air velocity from 0 m/s up to 16 m/s, which are near to thunderstorm conditions. In the electrode zone, a constant laminar air flow condition is guarantee, while atmospheric conditions are constantly monitored. See Figure 1.

B. Rogowsky Electrodes

To produce a homogeneous electric field in a plate to plate configuration, two round metal plates, 29.5 mm in diameter, are designed and constructed using a Rogowski profile. The upper electrode is connected to a negative high voltage source, while the lower electrode is grounded. In the grounded electrode a needle acting as a floating electrode, is placed and connected to the corona current measuring system. See Figure 2.

To compare the behavior of floating electrodes of different geometry, the needles shown in Figure 3 are used to perform the experiments. Needle 1 has 0.22 mm in diameter while

needle 2 is an irregular needle with an approximate diameter of 1.6 mm, both needles have a length of 6 cm.

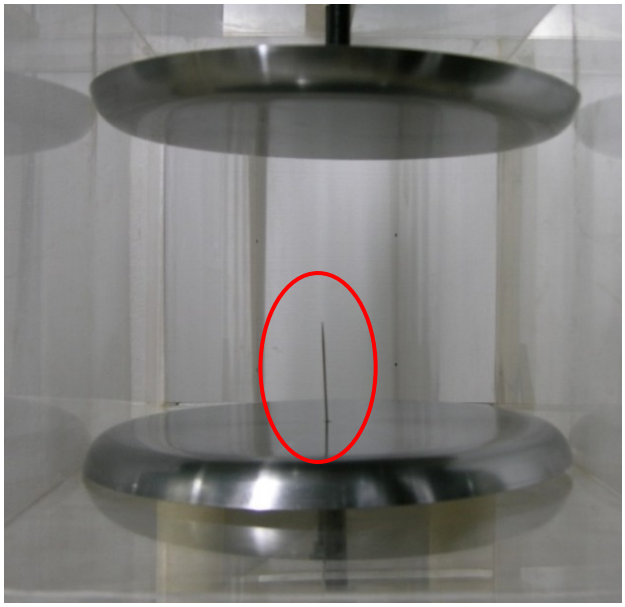

Figure 2. Detail of Rogowski Electrodes inside the tunnel. Notice the needle at the lower part.

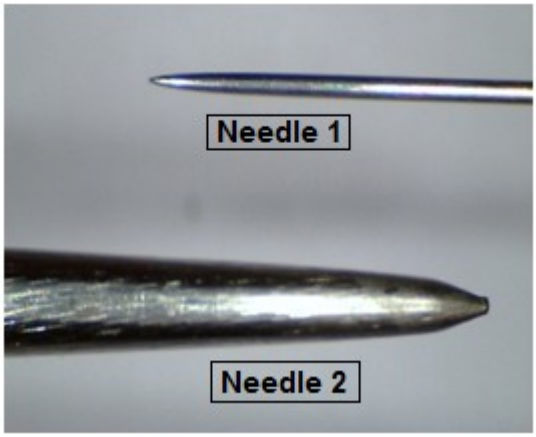

Figure 3. Detail of needles

III. EXPERIMENTAL PROCEDURE

Two corona experiments are performed. In the first one the corona onset voltage is determine, while in the second one the wind velocity effect on the generation of a DC corona current component is analyzed.

A. Corona Onset Voltage Test

The procedure consists on increasing the voltage of a HV source from 0 to 15 kV, while the corona current is measured. Wind velocities vary from 0 m/s to 15 m/s, in 3 m/s steps. The corona onset voltage is identified as the voltage where the corona current begins to flow, see Figure 4 and 5. In Figure 4, 5.95 kV is the corona onset voltage without air flow. The same corona onset voltage value was observed at all velocities as it is shown in Figure 5, for an air velocity of 15 m/s.

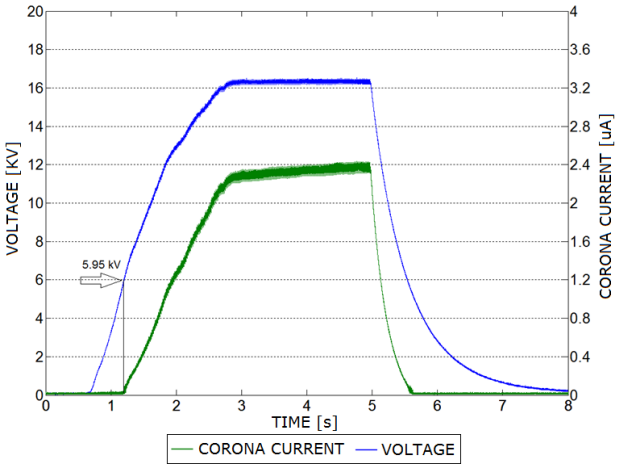

Figure 4. Test to obtain the corona onset voltage. A DC voltage (upper curve) was increased from o to 16kV in almost 3 seconds. Notice that the corona onset voltage occurs at 5.95 KV at 0 m/s. Needle 1.

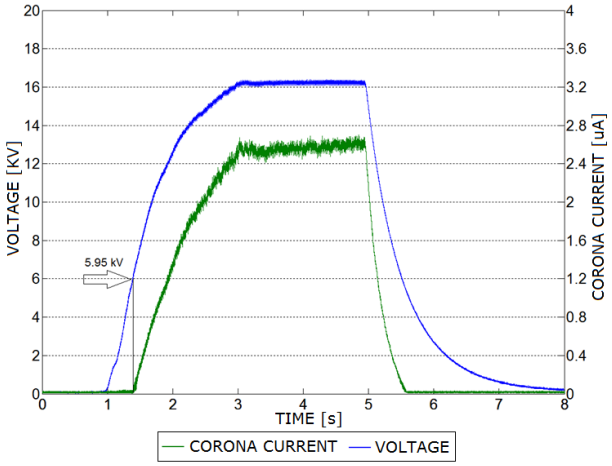

Figure 5. Test to obtain the corona onset voltage. A DC voltage (upper curve) was increased from 0 to 16 kV in almost 3 seconds. Notice that the corona onset voltage occurs at 5.95 KV at 15 m/s. Needle 1.

B. Wind velocity Test

In the wind velocity test a laminar air flow is applied in the wind tunnel to a needle while a DC voltage is applied across the plate-to-plate electrode arrangement. Wind velocities vary from 0 m/s to 15 m/s, in 3m/s steps. The experimental sequence is as follows:

- During the total duration of the experiment (120 s), a DC voltage is applied across the electrodes to establish a constant background electric field on the plate-to-plate electrode arrangement.
- During 60 s the air stream velocity is zero, while the corona current is measured. After this time period the air stream velocity is increase to one of the following 5 values: 3, 6, 9, 12 and 15 m/s.

- The wind velocity remains constant during 30 s, while the corona current is measured. After this time period the air stream velocity is reduced to zero.
- During the following 30 s, the corona current is measured, while the air stream velocity is zero. After this time period the HV source is switched off.

A new test cycle starts after a time period of 30s.

Figure 6 show the registered Corona Current values for the different air stream velocities.

Figure 7 is an example of the wind velocity test.

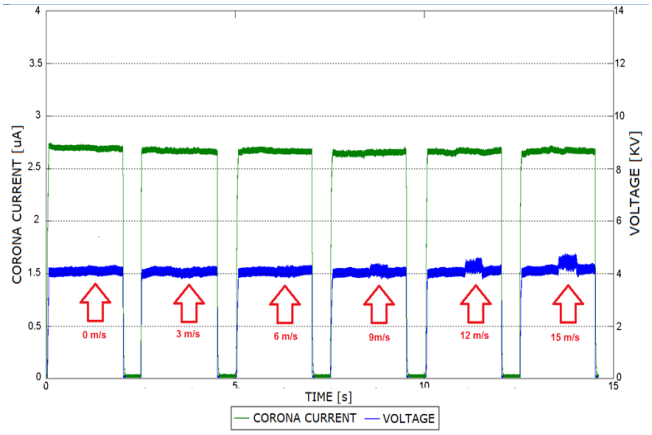

Figure 6. Corona Current measured at different air stream velocities and equal negative applied background voltage

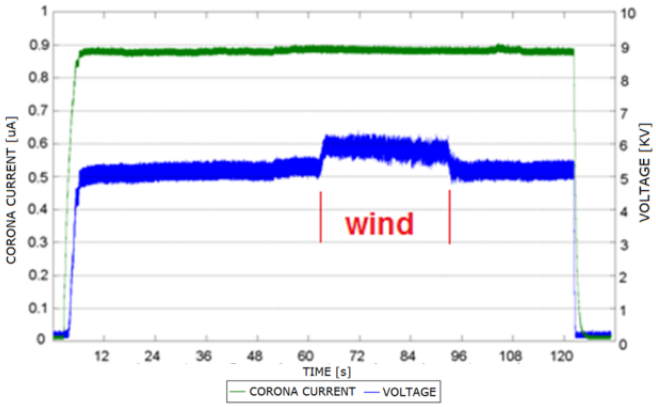

Figure 7. Example of wind velocity test. Notice the corona current increase during the 30 s period in which the air (wind) velocity is increased.

IV. RESULTS

Results show that the corona onset voltage is not affected by the wind velocity according to Figure 4 and 5. This has been demonstrated for the two needles shown in Figure 3.

The diameter of the needles has an influence on the corona current, showing a larger corona current in the thinner needle compared with produced by needle 2, see Corona Current scale in Figures 8 and 9.

To obtain the relationship between corona current, applied electric field and air stream velocity, Figure 8 and 9 were respectively obtained for needles 1 and 2. From these two figures it can be concluded that needle 1 produces almost three times more current than needle 2.

V. CONCLUSIONS

The performed experiments have shown that the corona onset voltage is independent of the wind velocity. Tests performed with the wind tunnel confirm the observations presented in previous works [1-3]. It was also observed the DC corona current component increase with the wind speed.

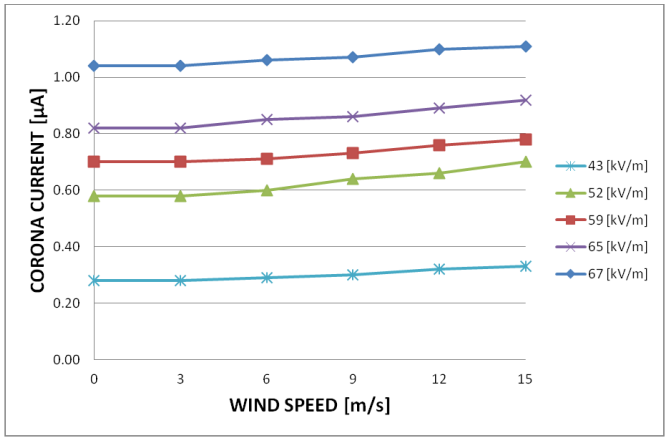

Figure 8. Corona current Vs wind speed (Air stream velocities) for needle 1, with five different background electric fields. Notice the current increase with the air stream velocity

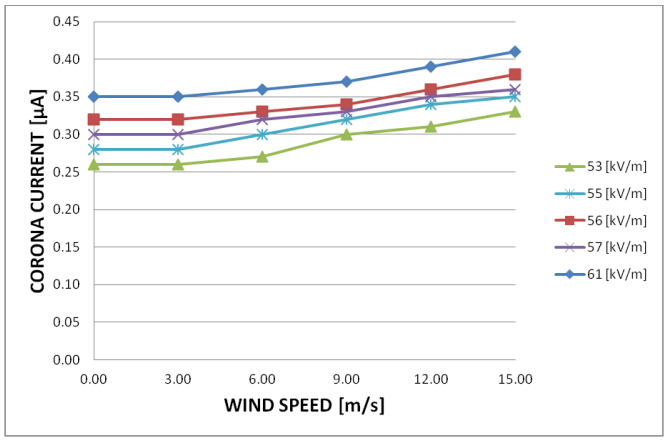

Figure 9. Corona current Vs wind speed (Air stream velocities) for needle 2, with five different background electric fields. Notice the current increase with the air stream velocity

It was also observed that the needles diameter has an influence: the thinner needle produces larger corona currents than the other one at the same background electric field. This effect will be analyzed in further works. Preliminary relationship could be obtained from the results shown in Figure 10.

The described wind tunnel and Rogowsky electrodes presented in this work are improvements of the experiments described in [2]. The observed stability in the corona onset

voltage and the Corona Current increase with air stream velocity reinforce the conclusions in previous works. The results obtained in previous works, especially the increase in the corona current magnitude and the role of the corona space charge on the corona current with air stream velocity requires additional analyses.

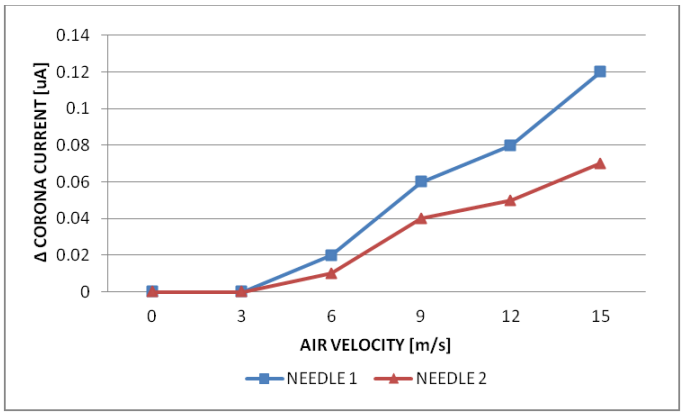

Figure 10. Test to observe the effect of the wind velocity on the generation of a DC corona current component on the needles shown in Figure 3.

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