First International Power and Energy Coference PECon 2006
November 28-29, 2006, Putrajaya, Malaysia

On a New Testing Setup for Lightning Air Terminal Corona Emission Patterns Studies

Muhammad Abu Bakar Sidik, *Student Member, IEEE*, and Hussein Ahmad, *Senior Member, IEEE*

***Abstract*--Harsh environmental conditions can damaged a lightning air terminal (LAT). If the tip of LAT is altered than the corona emission pattern will also be altered. The corona emission current is one of parameters to assess a LAT performance. Corona emission can only be formed when a particular humidity degree is achieved. Concerning this matter a new testing setup has been developed in the Institute of High Voltage and High Current (IVAT), Universiti Teknologi Malaysia, UTM Skudai. This present paper aims to introduce the new experimental set-up for the study of corona emission patterns and corona emission currents of five types of LATs. The results show that the blunt LAT produces almost zero corona emission current. That means that it is more attractive to lightning downward leader.**

***Index Terms*-- lightning, air terminal, corona emission, lightning rod.**

I. Introduction

CORONA emission current under a static electric field is one of the parameters to assess performance of a Lightning Air Terminals (LATs). Static electric field tends to increase during thunderstorm conditions prior to the approach of a lightning downward leader. In this connection, a study of corona emission from two types of LAT, e.g. Franklin rod and ellipsoidal LAT was carried out by Allessandro [1] for quantifying corona emission phenomenon under controlled conditions. There are others who have conducted experimental studies under uncontrolled condition [2-8].

Interestingly, a series of test conducted by Ong et al. to observe the performance of conventional LATs that have been damaged due to the acid rain effect [9]. They found that the blunt LAT has better performance to attract lightning downward leader than the others because the blunt LAT does not produce corona emission as others do. Conclusions were drawn from the results obtained through testing to determination the critical breakdown voltage of different LAT tip configuration.

Whereas this paper describes an improved method to assess the LAT performance based on corona current measurement technique. However the testing encountered with a problem to continuously maintain corona emission at LAT's tip for the prescript time. This is due to dependency of corona emission on humidity level of air. The pre-breakdown streamer heat-up the air surrounding the LAT's tip region thus humidity decreases. This in turn increases the air dielectric breakdown strength and as a result inhibits development of streamers at the LAT's tip.

To overcome this restriction an experimental set-up furnished with an air controller system is required. This present paper introduces a new experimental set-up which is developed in the Institut Voltan dan Arus Tinggi (IVAT), Universiti Teknologi Malaysia, Johor Bahru, Malaysia to study corona pre-discharge phenomenon. Inline with this, the corona emission on the different LAT tip configuration were observed.

II. A New Experimental Set-up

The schematic diagram of the novel experimental set-up which is able to continuously creating corona emission is shown in Fig. 1 (a). Briefly the set-up consists of an oval shape aluminium high voltage electrode (HVE) which is attached to two plastic-cable supported by a two-pulley-system (TPS), each on both sides. The TPS facilitates clearance variation to enlarge or narrow the air-gap distance between HVE and LAT. While nozzle-type sprinkler along with an electrical pump which is immersed in a tank filled with common tap water, helps to humidify the air. Fig. 1 (b) shows the set-up with a system to capture corona emission activities and leakage current signature capturing system.

To feed the HVE a HV generator system is used which is basically consists of 230V/100-kV, 5-kVA transformer and a rectifier circuit for high voltage DC generation by means of two 140-kV, 8-kW rectifier diodes and a 25000-pF smoothing capacitor.

The observations of the corona emission current were conducted with the attachment of LATs under test to the experimental rig grounding system via a 1.2-kΩ resistor. Therefore for 1-V measured across the resistor corresponds to 0.833-mA of corona emission current. For surge protection in case there shall occur unexpected breakdown of air insulation, a metal oxide varistor was connected shunting the resistor. To reduce the noise interference level the measuring shunt resistance was enclosed in metallic box with effective shielding properties against electromagnetic interference. Meanwhile the corona emission signatures were captured

Muhammad Abu Bakar Sidik is with the Institute of High Voltage and High Current (IVAT), Faculty of Electrical Engineering, Universiti Teknologi Malaysia, UTM Skudai 81310, Johor, Malaysia (e-mail: abubakar@unsri.ac.id).

Hussein Ahmad is with the Institute of High Voltage and High Current (IVAT), Faculty of Electrical Engineering, Universiti Teknologi Malaysia, UTM Skudai 81310, Johor, Malaysia (e-mail: hussein@fke.utm.my).

1-4244-0273-5/06/$20.00 ©2006 IEEE

using LeCroy oscilloscope LT344L 500-Mhz DSO. The scope has 4 channels for detection and measurement purposes, and a GPIB port for external connection with a computer for data transfer.

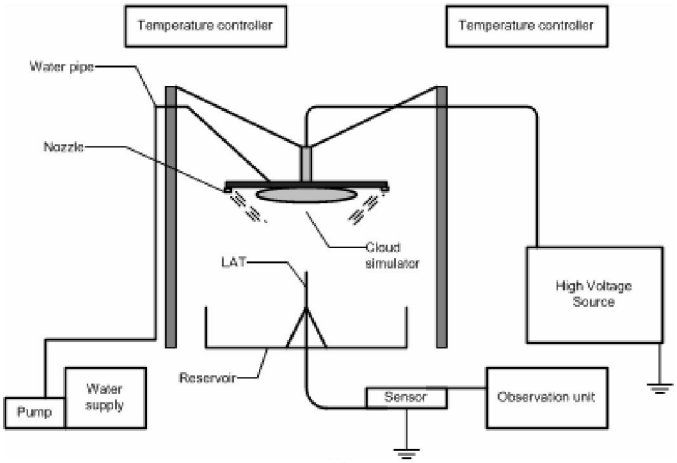

Fig. 1. The novel air humidifier testing system, (a) Schematic diagram of the controlled room, and (b) The experimental set-up of corona emission.

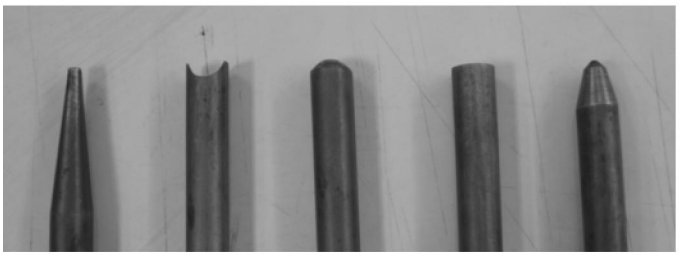

Fig. 2 Various types of LAT used in this study.

III. Experimental Procedure

There were five LATs used in this study, each with different tip configuration. Fig. 2 shows the various types of LATs used in the experiments. The LATs in turn was placed beneath the HVE.

By gradually increasing the power frequency main voltage, affect the output HVDC and when continuous emission of pre-breakdown streamer commenced after the emergence of negative glow and onset streamer, the voltage increment was stopped. At this point of time, the output voltage of the resistive divider and the peak corona emission current was observed and recorded.

IV. Result and Discussion

The photographic details of the corona emissions patterns can be seen in Fig. 3.

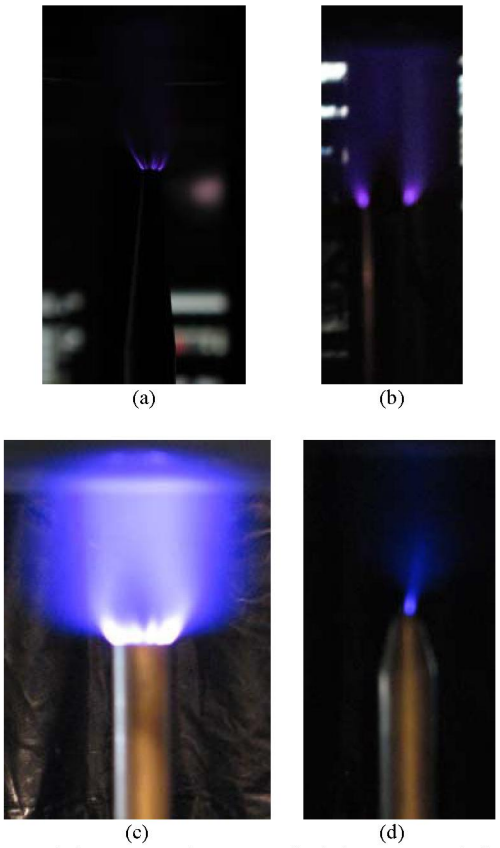

Fig. 3 Corona emission on LAT tips, (a) standard, (b) concave, (d) flat, and (e) conical.

The results of corona emission patterns show that they depend on the area that form shape edges. Fig. 4 shows the highlighted area of the LAT tips

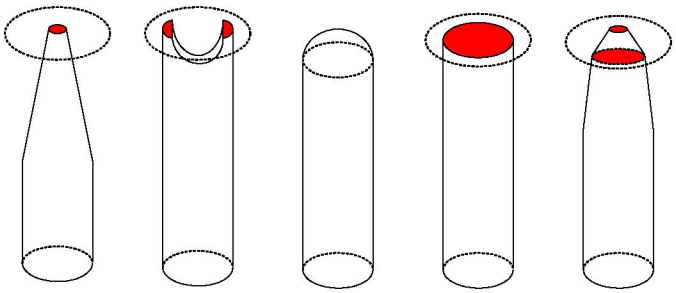

Fig. 4 The area of LAT that produce corona emission current.

The result of corona emission currents against the input voltages presented as well (see Fig. 5). The test concern proved that (from Fig. 5), the blunt produces almost zero pre-emission streamer emission current which also mean it is more attractive to lightning downward attachment. Thus it is

recommended to adopt this for those interested to study corona emission activities of any HV system components.

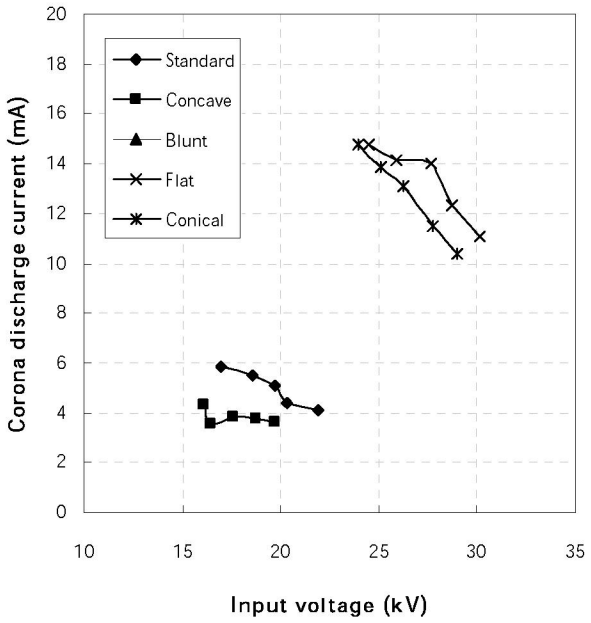

Fig. 5. Input voltages against corona emission currents

V. Conclusion

A new testing set-up for LAT corona emission study has been presented. However, the standard Franklin rod used in this work is a typical Franklin rod practically installed in Malaysia. The finding strengthened the fact that for better capturing of lightning leaders, blunt tip LAT is preferable.

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VII. Biographies

Muhammad Abu Bakar Sidik (S'2002) was born in Palembang, South Sumatera, Indonesia, on August 14, 1971. He received the B.Eng degree in Electrical Engineering from Universitas Sriwijaya in 1996 and the M.Eng in High Voltage Engineering from Universiti Teknologi Malaysia in 2003. He is currently a Ph.D student engaged in research at Institut Voltan dan Arus Tinggi (IVAT), Faculty of Electrical Engineering, Universiti Teknologi Malaysia, UTM Skudai Johor Darul Takzim,, Malaysia.

Hussein Ahmad (M'87—SM'95) was born in Mersing, Johor Bahru, Malaysia, on July 1, 1953. He obtained B.Sc.(Hons) and M.Sc. in Electrical Engineering from University of Strathclyde, Scotland and subsequently obtained his Ph.D. degree in High Voltage Engineering from University of Manchester Institute of Science and Technology (UMIST) in 1986. Currently, he is a professor and a director of Institut Voltan dan Arus Tinggi (IVAT) in Faculty of Electrical Engineering, Universiti Teknologi Malaysia, UTM Skudai, Johor Darul Takzim, Malaysia.